SECO Optometry Board Review - Optics

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Disclosure Statement:
No Disclosure Statement.

Please mute yourself

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Item numbers

- 17-25 out of 350 items

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Snell's Law of Refraction

- Snell's law of refraction deal how light interacts with the material/medium as it passes from one medium into another.
  - In simple terms, it refers to the bending of light as it passes through different objects or materials. As light passes from one medium to another, it is either slowed down or sped up, which causes the light to bend.
- $n_a \sin \theta_a = n_b \sin \theta_b$
- n_a = index of refraction in material a
- n_b = index of refraction in material b
- θ_a = angle of light relative to normal to the barrier in material a, (radians or degrees)
- θ_b = angle of light relative to normal to the barrier in material b, (radians or degrees)
- The angles in Snell's Law are always measured relative to the normal (perpendicular) to the surface.

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Examples of Refraction

- Rainbows
- Atmospheric refraction
- Distortion of underwater objects
- Telescopes
- Prisms
- Refraction is caused by the bending of light as it passes through mediums with different indices of refraction

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Simple formula

Simple formula

The formula is:
$N_1 \sin i = N_2 \sin r$
Where:
N_1= index of refraction of incident medium
i = angle of incidence
N_2 = index of refraction of refracting medium
r = angle of refraction

The main thing to remember here is that the greater (higher) the index of refraction, the more light will bend through the medium

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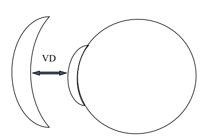
Vertex Distance

- When to compensate?
  - Spectacles - Over +/- 7.00
    - In either principal meridian
  - Contact Lenses - Over +/- 4.00
    - In either principal meridian



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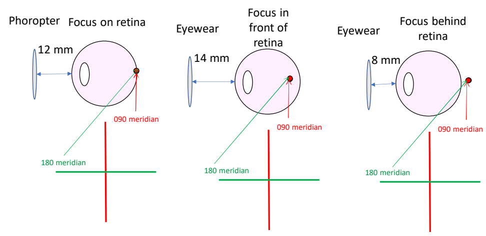

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Vertex Power Compensation

- **Simple formula**
- The simple formula for determining the effective power when moved by millimeters is: diopters squared, divided by 1000. That value is multiplied by the millimeter of change.
- EP = D^2 / 1000 X mm of change
  - Whereby EP = Effective power
  - D^2 = dioptric power of lens meridian squared

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Vertex Power Compensation

- The compensated power is the result of adding to or subtracting from the dioptric power as follows:
  - 1 – Minus lens moving closer - subtract to reduce the dioptric power
  - 2 – Plus lens moving closer - add to increase the dioptric power
  - 3 – Plus lens moving farther away - subtract to reduce the dioptric power
  - 4 – Minus lens moving farther away - add to increase the dioptric power

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Vertex Power Compensation

- **Example 1:**
- A -12.00 D sphere lens is refracted at 12mm and the lens will sit at 9 mm from the apex of the patient's cornea.
- 12 squared = 144, 144/1000 = .14
- The movement is 3mm closer to the patient's eye, with a minus lens.
- 3 x .14 = .42
- EP = -12.42 D
- Because the effective power is greater than was needed by the patient the compensated power must be reduced by the difference. Therefore, the **COMPENSATED** power is calculated thusly
- .42D or 0.50 D is subtracted from -12.00 to compensate the lens power to -11.50 D.

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Magnification Effect of Vertex Change

- Another concern is the effect of the magnification/demagnification effect of changing the vertex distance
- Plus lenses magnify images
  - Plus lenses moved closer to the eye reduce the effect of magnification
  - Plus lenses moved further away from the eye increase the effect of magnification
  - Minus lenses moved closer to the eye reduce the effect of demagnification (also referred to as minification)
  - Minus lenses moved further away from the eye increase the effect of demagnification

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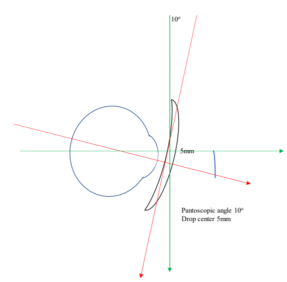
Position of Wear

- Tilt
- Wrap
- Prismatic effect



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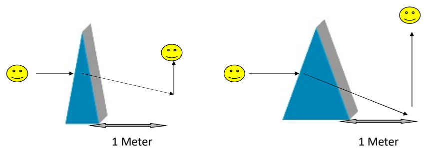
Prism

- The greater the difference in thickness between the base and the apex
  - Stronger the power of the prism



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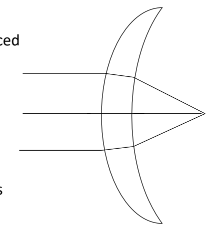
Characteristics of Plus Lenses

- Convex or plus lenses are made up of two prisms placed base to base
- Converges light rays
- Creates a real image
- **Magnifies image**
- Center thicker than edge
- Weakens as vertex shortens
- Against motion



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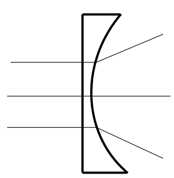
Characteristics of Minus Lenses

- Concave or minus lenses are made up of two prism placed apex to apex
- Diverges light rays
- Creates a virtual image
- **Minifies images**
- Thicker at edge than center
- Strengthens as vertex shortens
- With motion



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Characteristics of Contact Lenses

- Float on precorneal tear film
- Move with the eye
- NO vertex distance, so image size is almost the same
  - Power needs compensating more frequently for CL's than for spectacles

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Prescriptions that create difficulties in magnification and minification

- Isometropia
  - Equal
- Anisometropia
  - Unequal
- Antimetropia
  - Opposite
- Aniseikonia
  - Unequal image sizes

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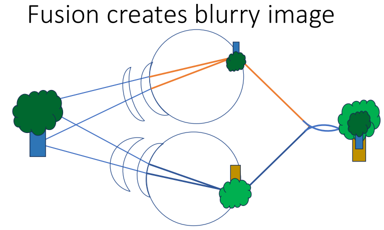
Fusion creates blurry image



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Iseikonic lenses

- A lens or pair of lenses used to correct aniseikonia
- The following variables are used:
  - Base curve
  - Thickness
  - Vertex distance
  - Index of refraction

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Esophoria or esotropia

- Base-out prism
  - All in one eye or split between the two eyes.
  - If split between both eyes, the orientation for the prism will still be base-out for both eyes. An example of “eso” correction in a prescription is:
- OD: -2.00 – 0.25 x 180 Δ1.50 BO
  OS: -2.25 – 0.50 x 175 Δ1.50 BO

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ABBE VALUE

- The measure of a material’s characteristic of breaking light into its component colors
- Abbe value of lens material (also referred to Nu value or V number
  - Reciprocal of the dispersive power of the lens
  - Range from 20 – 60
  - Higher number = less chromatic dispersion
- Has been a constant concern with high index lens materials
- If the color aberration is significant enough, the lens wearer will likely see some reduction in vision quality and possibly colored ghost images around objects

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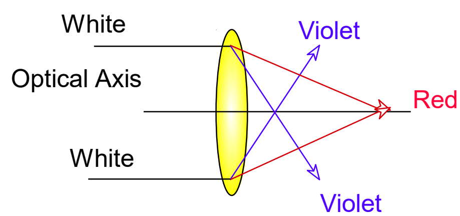
Chromatic Aberration



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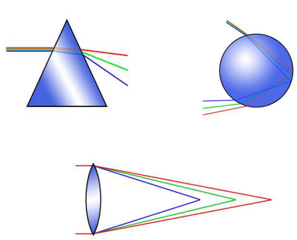
Different focal points of different wavelengths (colors)



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Chromatic Aberration

- Two aspects
  - Longitudinal chromatic
    - Occurs if a lens cannot focus different colors in the same focal plane. It is caused by straight incident light. The foci of the different colors lie at different points in the longitudinal direction along the optical axis.
    - The longitudinal chromatic aberration leads to colored areas in the images, that arise, because not all colors can be displayed in focus.

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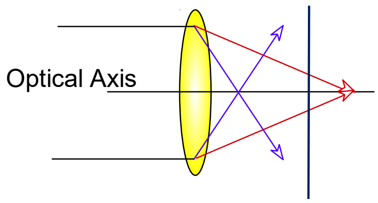
Longitudinal
Chromatic Aberration



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Chromatic Aberration

- Two aspects
  - Lateral chromatic
    - Obliquely incident light leads to lateral chromatic aberration. In that case all colors are in focus in the same plane, but the foci are not placed along the optical axis.
    - This kind of aberration does not lead to colored areas, but to fringes that occur around objects of high contrast as the magnification is dependent on the wavelength.

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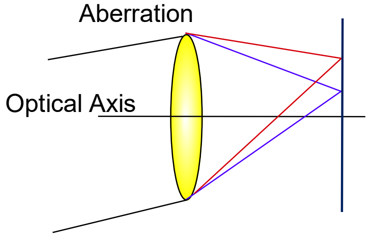
Lateral Chromatic
Aberration



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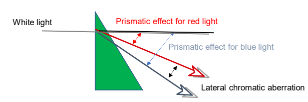
Lateral Chromatic Aberration

- Occurs when a prism (lens) bends light of two different wavelengths by different amounts
- Result in colored “ghost” images



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Chromatic Aberration

- Material dependent
  - Abbe value
- Results in out of focus image
- Higher powers create more chromatic aberration
- Patient complaints include peripheral color fringes (off-axis)

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Chromatic Aberration

- Possible correction
  - Lens material change (Abbe)
  - AR lens (coating)
  - Smaller frame
  - Fit closer – vertex distance
  - Ensure correct measurements
  - Pantoscopic tilt
  - Educate the patient

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Marginal Astigmatism

- Astigmatism in a lens (marginal or oblique, depending upon the source)
- Arises because an object point is a distance from the optical axis
  - The cone of the rays from that point will strike the lens asymmetrically
- Leads to rays which are less parallel to the optical axis being focused differently from those which are parallel (or almost) to the optical axis
- Produces blur for some points

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Marginal Astigmatism

- Concern for lens designers
  - Because it involves narrow beams of parallel light striking the lens at an oblique angle
  - More difficult for viewer to deal with (pupil cannot affect it)
  - When a narrow beam of parallel rays strike a lens surface obliquely, the rays focus in two opposite opposing points
    - Difference between the two points equals the degree of astigmatism created
  - Reason for the development of corrected curve lens series

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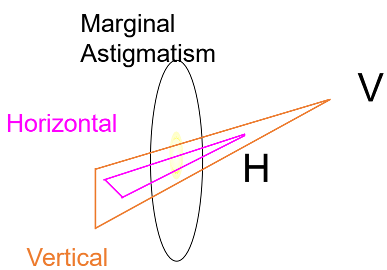

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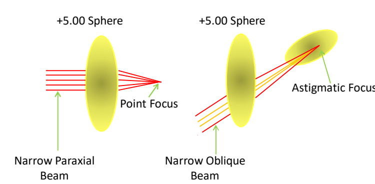
Marginal Astigmatism



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Marginal Astigmatism

- Possible corrections
  - Corrected curve design
  - Digital design
  - Aspheric lens design
  - Drop OC 1mm for every 2 degrees of pantoscopic tilt
  - Use correct face form

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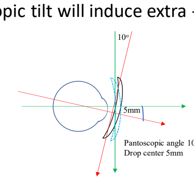
- For a plus lens, incorrect pantoscopic tilt will induce extra + sphere and + cylinder on the 180 axis.
- For a minus lens, incorrect pantoscopic tilt will induce extra - sphere and - cylinder on the 180 axis.



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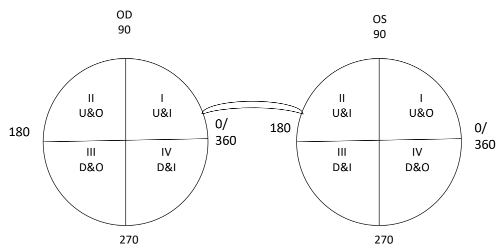
Resultant Prism



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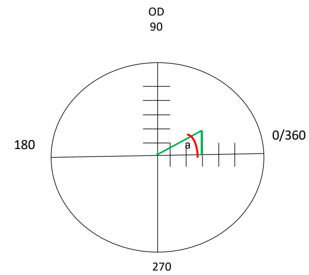
Resultant Prism



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Resultant Prism

$$R = \sqrt{\text{Vertical Prism}^2 + \text{Horizontal Prism}^2}$$

Example 2 diopters up and 3 diopters in

$$R = \sqrt{2^2 + 3^2}$$

$$R = \sqrt{4 + 9}$$

$$R = \sqrt{13}$$

R = 3.61 diopters

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- First identify how much prism. The resolved amount of prism is determined by using the above formula. That amount of prism is then ground at the axis that is arrived at by drawing the diagonal of the parallelogram graphed using the prescribed prisms.
- In this example we have 3 diopters in and 2 diopters up in the right eye.
- Although we show the entire process, here, let's go through the steps using your scientific calculator.

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Begin by simply looking at the formula and plugging in the known values to the formula

$$R = \sqrt{2^2 + 3^2}$$

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The next level is pretty straight forward. Look for your squared button with is x^2. Next do the math.
2 squared is 4 and 3 squared is 9. Added together they are 13.

$$R = \sqrt{2^2 + 3^2}$$

$$R = \sqrt{4 + 9}$$

$$R = \sqrt{13}$$

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Resultant Prism

R = $\sqrt{13}$

Leaving 13 on your calculator use the

$\sqrt{x}$

on your calculator. The result will be 3.605551275 rounded to 3.61 diopters

R = 3.61 diopters

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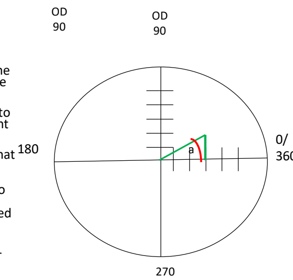
Resultant Prism

- the green lines here represent the resultant prism and form a right triangle.
- The resultant prism is the length of the longest line in the right triangle.
- This would also equate to the hypotenuse of a right triangle.
- The resultant formula that we just did shows that there is 3.61 prism diopters, but we need to know the degree of the axis, which is represented by the red angle a.
- To find out that, we continue to use another formula.



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Resultant Prism Degree

- tan a = V/H
- tan a = 2/3
- First divide 2 by 3 = .666666667 don't round yet
- Then go to 2nd function on your calculator and THEN TAN.
- The answer is 33.690006753 rounded to 33.69
- Note, you may have a button on the calculator labeled "inv" or "arc" rather than using the 2nd function button.

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Resultant Prism Degree

- Look at your quadrants. If the answer falls within the quadrant you want, i.e. I, that is your answer. If, however it is in another quadrant, you will add 90 to your answer for quadrant II, 180 to your answer for quadrant III and 270 to your answer for quadrant IV.

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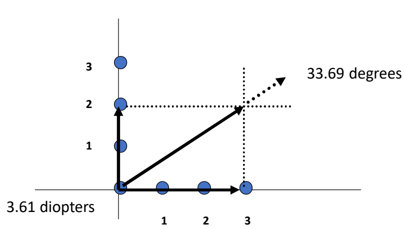
3.61 diopters ground at 33.69 degrees



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- Resultant Prism or Compounding Prism shows the prism's polar orientation (Rx II) Vs. rectangular orientation (Rx I).
- Compounding prism is expressed in dioptric power and it's orientation in degrees.

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Optics – the study of light

- Geometric optics deals with the part of optics that deal with light rays or "beams" of light
  - Reflection, refraction, prisms, lenses, mirrors, optical devices such as microscopes, telescopes, cameras
- Physical optics deals with the wave nature of light
  - The phenomena of diffraction, scattering, interference, polarization, color, etc.
  - Electromagnetic spectrum falls under physical optics

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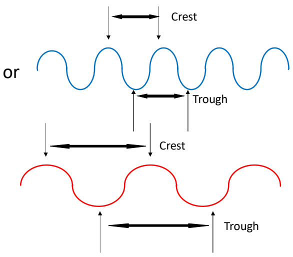
Wavelengths

- Distance between pulsations
- From crest to crest or trough to trough
- Measured in nanometers
- 0.000000001 m.



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Frequency

- Number of vibrations of wavelength in 1 second

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Velocity

- Speed at which a wave travels forward

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Light

- Light diverges from a source in waves
- Velocity = Wavelength X Frequency
- The velocity of all EM radiation is the same in air
- Speed of light in air = 186,000 miles per second

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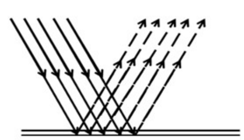
Mirrors

- The law of reflection is:
- The angle of incidence = the angle of reflection



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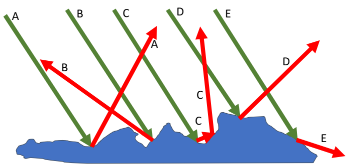
Diffused Reflection

- Light falling on opaque or irregular surface, will be reflected in a random manner, not creating a perfect reflection.



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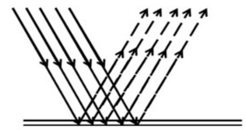
Mirrors

- The law of reflection is:
- The angle of incidence = the angle of reflection



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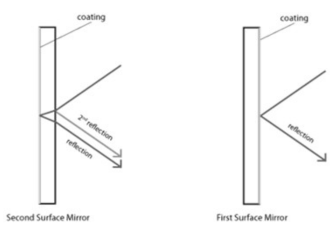
Types of Mirrors



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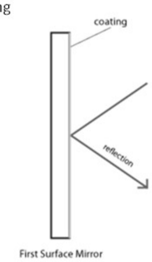
First Surface Mirrors

- Used for strict reflection without ghosting effect
  - Telescopes, projection televisions and periscopes use this type
- Advantage
  - Produces clearer image
  - Images are reflected at full intensity and brightness
- Disadvantages
  - More easily damaged
  - Cost is usually higher



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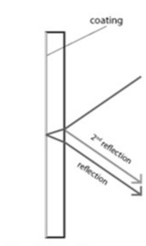
Second Surface Mirrors

- Most of what we use today
- Generally constructed of protective clear glass or acrylic over silvered coating on back surface
- Advantage
  - Silver is protected
  - Cost is less
- Disadvantage
  - Ghost image due to front reflection (about 4%)
  - Internal reflection



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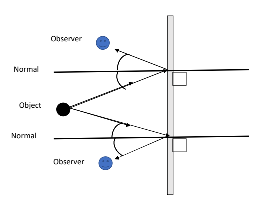
Total internal reflection (through prism)

- Critical Angle
  - Defined as 42 degrees



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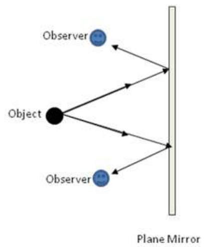
Plane Mirrors

- Mirrors that are flat
- Plano surface



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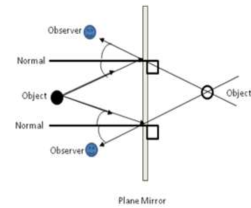
Plane Mirrors

- Produce virtual images
- Image appears to be the same distance behind the mirror
- Size and perspective is the same



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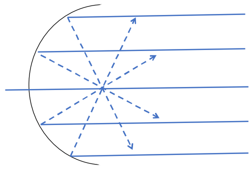
Curved Mirrors

- Convex mirrors are known as diverging mirrors, while concave mirrors cause parallel light rays to converge. This is opposite from ophthalmic lenses. The name of the mirror indicates the side of the sphere that is reflective.



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Curved Mirrors

- Convex mirrors produce smaller images, so the image may appear further away.
  - The kind of mirror used in the rear-view mirror must therefore be a convex lens.
- Concave mirrors produce images which are larger than they actually are.
  - Makes them useful as makeup mirrors.

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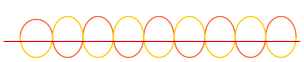
Light – Reflection - Interference

- Out of Phase
  - Canceling
  - Destructive
  - No Reflection
  - AR Coating



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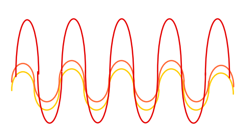
Light – Reflection - Interference

- In Phase
  - Compounding
  - Constructive
  - Reflection
  - Mirror Coating



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-10.00 sphere tilted 10 degrees and OC in front of pupil – Martin's Formula

- New Sphere Power (S_1) = $S\{1 + \frac{(\sin \alpha)^2}{2n}\}$
- Where:
- S_1 = New Sphere power
- S = Original sphere power
- α = Degrees of tilt
- n = Index of refraction (* Some formulas use 3 for 2 times CR-39 index, 1.498)
- Induced cylinder power $C_1 = S_1 (\tan \alpha)^2$
- Where:
- C_1 = Induced cylinder on the axis of rotation
- α = Degrees of tilt

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-10.00 sphere tilted 10 degrees and OC in front of pupil – Index of refraction is 1.50

- New Sphere Power (S_1) = $S\{1 + \frac{(\sin \alpha)^2}{2n}\}$
- Where:
- S_1 = New Sphere power
- S = Original sphere power
- α = Degrees of tilt
- n = Index of refraction (* Some formulas use 3 for 2 times CR-39 index, 1.498)
- Induced cylinder power $C_1 = S_1 (\tan \alpha)^2$
- Where:
- C_1 = Induced cylinder on the axis of rotation
- α = Degrees of tilt

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-10.00 sphere tilted 10 degrees and OC in front of pupil – Index of refraction is 1.50

- New Sphere Power (S_1) = $S\{1 + \frac{(\sin \alpha)^2}{2n}\}$
- Where:
- S_1 = New Sphere power
- S = Original sphere power
- α = Degrees of tilt
- n = Index of refraction (* Some formulas use 3 for 2 times CR-39 index, 1.498)
- Induced cylinder power $C_1 = S_1 (\tan \alpha)^2$
- Where:
- C_1 = Induced cylinder on the axis of rotation
- α = Degrees of tilt

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-10.00 sphere tilted 10 degrees and OC in front of pupil – Index of refraction is 1.50

- New Sphere Power (S_1) = $S\{1 + \frac{(\sin \alpha)^2}{2n}\}$
- New Sphere power = $-10.00(1+\frac{\sin^2 10}{3}) = -10.10$D
- Induced cylinder power $C_1 = -10.10 (\tan 10)^2 = -0.31$D
- The resultant prescription is: -10.10 -0.31 x 180

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Prentice's Rule

P Δ = hD

Where P = prismatic effect
H = distance from optical center in centimeters
D = power in meridian of prism base

Direction

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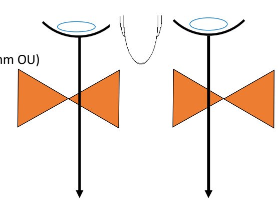
Prentice's Rule

Example

- Rx -4.00 sphere OU
- Patient's PD is 62mm (31mm OU)
- Glasses check out with PD as 66mm (33mm OU)
- What is the prismatic effect

P Δ = hD
H = 2 mm each eye (convert to cm)
H = .2 cm each eye
D = -4.00 OU
P Δ = .2 X 4.00
P Δ = .8 Δ BI each eye



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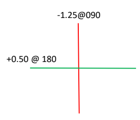
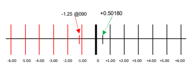
Transposition

Lensometer Readings
+0.50 @ 180/-1.25@090





- The difference between the two principle meridians is 1.75
- If you start at -1.25 and move to the +0.50 You move in the plus direction.
- If you start at the +0.50 and move to the -1.25 You move in the minus direction.
- Therefore the Rx will be written in either plus cylinder or minus cylinder depending upon where you start.

Rx is:
+0.50 -1.75 X 180
Or
-1.25 +1.75 X 090

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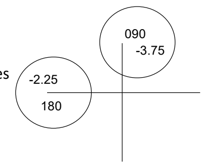
Transposition

- It's important to remember that transposition doesn't change the value of the lens, it simply changes the form that the prescription is written in
- Remember the lens cross???
- Regardless of whether the Rx is written in + cylinder or – cylinder the powers remain the same in any meridian on the lens cross.
- This prescription can be written
  -2.25 – 1.50 x 180 or
  -3.75 + 1.50 x 090
  It's the same lens



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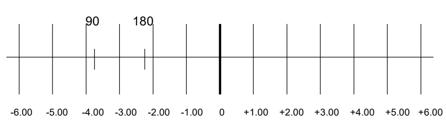
Transposition

- Using the number line as though it were on a lens meter, take the same prescription and orient it here
- If you rotate the axis wheel to 180 meridian, the sphere lines will come clear at -2.25 and 90 degrees away at the 90 meridian the cylinder lines will be clear at -3.75



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Transposition

- When discussing changing a prescription that is written in plus cylinder form to minus cylinder form, we use the term Flat Transposition, or as it has been more commonly shortened Transpostion.
- This changes the format without changing the value of the prescription.

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Designation of Axis in Rx

- When observing the written form of the prescription you may observe that it can be written with the axis as cx

  -2.25 – 1.50 cx 180 or
  -3.75 + 1.50 cx 090

- Or you may observe that it is written with the axis reference as simply x

  -2.25 – 1.50 x 180 or
  -3.75 + 1.50 x 090

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Correction- Contact Lenses

- Optically one of the best options available for correcting vertical imbalances and aniseikonia.
- Vertex distance is 0.0 mm, therefore there is virtually no image size difference.
- OC moves with the eye, so virtually no image displacement.
- In the case of multifocal Rx, when used with S.V. readers or multifocals prismatic difference disappears.
- Monovision method effective in eliminating prism effect.

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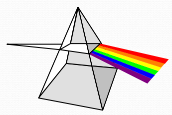
Dispersion

- Visible light is referred to as white light
- When it hits a prism, it is slowed and bent
- Each color and wavelength is bent to a different degree
- The result of this is a rainbow resulting from the dispersion of the wavelengths
- The wavelengths from longest to shortest are red, orange, yellow, green, blue, indigo, and violet
  - ROYGBIV



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Dispersion

- White light
  - The longer the wavelength, the faster it travels
    - The faster it travels, the less it bends
  - The shorter the wavelength, the slower it travels
    - The slower it travels, the more it bends

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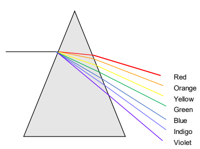
Dispersion

- Red is the longest wavelength
  - travels fastest
  - bends less
- Violet is the shortest wavelength
  - travels slowest
  - bend most



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Lens Design Factors and their Effect on Magnification

- Thickness
  - as the lens thickness increases magnification increases
- Base Curve
  - as the front curve gets steeper the magnification increases
- Vertex Distance
  - a plus lens moved farther from the eye increases the image size
  - a minus lens moved closer to the eye increases the image size

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Iseikonic lenses

- A lens or pair of lenses used to correct aniseikonia
- The following variables are used:
  - Base curve
    - Shape
  - Thickness
  - Vertex distance
  - Index of refraction

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Magnification formula

Magnification (M) = (Shape Factor) * (Power Factor)
Shape Factor = 1 / (1 - ((c * D_1) / n))
Power Factor = 1 / (1 - z D_v)

D_1 = front surface power (base curve) in diopters
c = center thickness in meters
n = index of refraction of lens
z = vertex distance in meters
D_v = back vertex power

% Magnification = (M - 1) * 100
Difference in Magnification = % M_1 - % M_2
Approximate shape factor change = (X * D_1) / 15
Approximate power factor change = (z * D_v) / 10

X = change in center thickness in mm
D_1 = change in base curve
D_v = back vertex power
z = change in vertex distance in mm

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Formulae to Calculate the % of Change in Magnification

Change in Thickness $m\% = \dfrac{t \times D_1}{15}$

Change in Front Curve $m\% = \dfrac{t \times D_1}{15}$

t = center thickness or change in center thickness (+ for increase, - for decrease)

D_1 = front curve or change in front curve

85

Change in Thickness

$$m\% = \frac{t \times D_1}{15}$$

D_1 = +9.00, t = 2.0 mm increase in thickness

$m\% = \dfrac{t \times D_1}{15} = \dfrac{2.0 \times 9.00}{15}$ = 1.2 % increase in magnification

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Change In Front Curve

$$m\% = \frac{t \times D_1}{15}$$

D_1 changed from +6.00 to +10.00, t = 3.0 mm

$m\% = \dfrac{t \times D_1}{15} = \dfrac{3.0 \times 4.00}{15}$ = 0.8 % increase in magnification

87

Formula for using standard chart and changing calculations

- Divide the test distance into 20 feet or 6 meters
- For example if the test is at 5 feet = ¼ of 20 feet, so adjustment is calculated on both the numerator and the denominator of the fraction.
- Say the patient can see the 20/50 line but the text is done at 5 feet
- Then both the numerator and the denominator are multiplied by 4 which would be 20/200

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Thickness and power

- The back surface or ocular surface of a lens sits closest to the eye.
- Therefore, it is important that we be able to calculate the power of the lens based upon the position in front of the eye.
- In neutralizing the power of a lens on a lensometer, we position the back surface of the lens against the lens stop. That gives us the back-vertex power.
- In thinner lenses, there is very little difference between front surface power and back surface power as read in a lensometer.
- However, as the thickness of the lens increases, there can be a significant difference between the two readings.

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Thickness and power

- Vergence: The definition - The amount of divergence (negative) or convergence (positive) of a pencil of light rays entering or leaving a lens.
- For thick lens designs, we must also consider the equivalent thickness (t/n), which is the vergence of the light passing through the thickness of the lens. Because of the steep front curve and the thickness of the center, the thick lens will add convergence to the wave front as it passes through the lens. To find the back-vertex power (BVP) in addition to the simple combination of the powers of the front and back surfaces, we must also include the factors of the thickness of the lens in meters and the index of refraction of the material.

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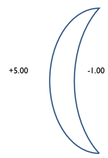
Thickness and power

- For example, using the nominal power/thin lens formula we would calculate the power and it would appear as the illustration directly below.



Approximate power +4.00

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Thick lens formula

- However, when the power of a lens is over +/- 4.00D or if a steeper base curve is used, we need to consider the thickness as well, due to vergence within the lens.
- Therefore, for the thick lens formula, we must include the equivalent thickness (t/n) to the formula.
- The thick lens/back vertex formula is:
- $D_e = D_1 + D_2 + (t/n \times D_1^2)$

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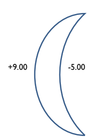
- The illustration below demonstrates the thick lens design. If we simply used the thin lens formula, the power would appear to be +4.00D, however, due to the high surface curvature, the thickness is increased, which not only increases the magnification effect of the lens but the power as well. Therefore, the approximate power using the thick lens formula would be +4.39D.



t = 7.0mm
n = 1.50
Approximate power +4.39

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Sagittal depth simple formula

- S = $\dfrac{\text{Radius}^2 \text{ X Power}}{2000\ (N - 1)}$
- Where:
- S = thickness
- N = index of refraction of lens material used
- Thickness is in mm

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Sagittal depth simple formula

- S = $\dfrac{30^2 \text{ X } 4.00}{2000\ (0.56)}$
- S = $\dfrac{3600}{1120}$
- S = 3.214 mm = 1.00 mm = 4.214 mm

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Sagittal depth simple formula

- S = $\dfrac{30^2 \text{ X } 4.00}{2000\ (0.67)}$
- S = $\dfrac{3600}{1340}$
- S = 2.687 mm = 1.00 mm = 3.687 mm

Compared to 1.67 index of refraction – thickness difference is 0.527 mm

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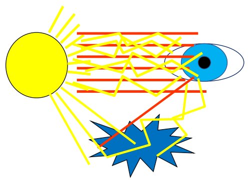
Glare And Reflections

- Visible glare
  - Sunlight that is reflected off of surfaces such as car windshields, snow, and sand
  - Dangerous
    - Washes out colors
    - Photokeratitis
    - Temporary snow blindness
    - Blinding glare



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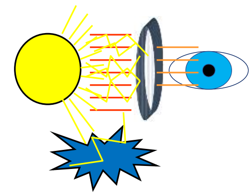
Polarizing Filters

- Virtually eliminate reflective glare
  - Blinding glare



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Principles of Polarization

- ✖Venetian blind
- ✖Film is oriented to block reflections from horizontal surfaces
- ✖Sunlight reflecting from:
  - +Water
  - +Roads
  - +Snow
  - +Car hoods
  - +Any horizontal surface

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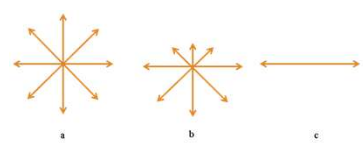
Unpolarized Light
Partially Polarized Light
Plane or linearly Polarized Light
David Brewster of Scotland described the polarization of light by reflection in 1815
1932
E H Land (USA). Invents "polaroid" polarizing film when he was 19



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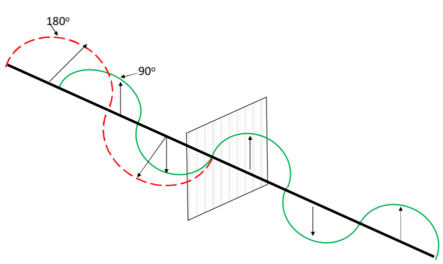
Polarizing Filter



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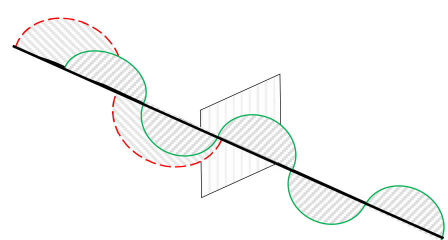
Polarizing Filter



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Polarized Lenses

- Not recommended for visual tasks that involve the use of LCD (Liquid Crystal Diodes) instrumentation
  - The polarizing filter blocks them out
  - Examples
    - Gas pumps
    - Some automobile panels
    - Some airplane panels
    - Some watches

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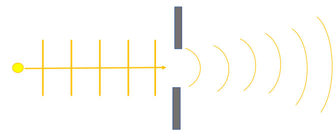
Diffraction

- Diffraction can occur with any type of wave. Think of the ocean where there are jetties. The waves strike the jetties and go around them in a different pattern that can be defined. Sound waves travel around objects and one can still hear. Light diffraction occurs when light is bent without entering another medium. An example would be light bending around a doorway into a dark room.



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Multifocal Lenses

- 1. Types (fused, 1-piece, progressive additions and blended lenses)
- 2. Methods of producing Add powers
- 3. Segment center location
- 4. Differential displacement (jump)
- 5. Total displacement, horizontal and vertical imbalance
- 6. Placement of distance and multifocal optical center
- 7. Optical and physical characteristics of segments (design and calculations, progressive Adds, aberrations, surface characteristics)
- 8. Specifying multifocal height, size, shape and location of segment

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National Standards

- ASTM
  - American Society for Testing Materials
- ANSI
  - American National Standards Institute
- OSHA
  - Occupational Safety and Health Administration
- FDA
  - Food and Drug Administration
- FTC
  - Federal Trade Commission

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Enviornmental Protection Agency (EPA)

- Hazardous Materials
- MSDS sheets – Now called SDS sheets
  - Identify chemicals used
- Disposal

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ANSI – Protection

- ANSI Z80.1 covers dress eyewear
- **ANSI Z-87 Safety Eyewear Basic Impact**
  - 1" Steel Ball Dropped from 50 Inches
  - Lens Thickness: 3.0mm regardless of material (2.5mm edge on high plus)
  - Lens Markings: Sandblasted manufacturer's I.D., additional marks for tinted, photochromic, or special purpose lenses.
  - Frame Markings: Front - A, DBL, Z87+, Manufacturer's I.D. Temples - Length, Z87+, Manufacturer's I.D.

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ANSI

ANSI Z-87 High Impact

- Called Z87+
- 1/4" Steel Ball at 150 Feet/Second
- Lens Thickness: 2.0mm.
- Lens Markings: Sandblasted manufacturer's I.D. and "+"
- All Frames, Basic or High Impact must meet High Impact Standards
- Frame Markings: Front - A, DBL, Z87+, Manufacturer's I.D. Temples - Length, Z87, and Manufacturer's I.D.

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ANSI

- ANSI Z87.1 Testing Standard for Safety Eyewear
- Weighted/pointed projectile
  - weighing 500grams (17.6 oz)
  - Dropped from 50 inches

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ANSI Z80.1

- Vertical Segment Height
  - +/- 1mm, match 1 mm
- Horizontal Segment location
  - +/- 2.5mm, Sym
- Thickness
  - +/- 0.3mm
- Warpage
  - 1.00 D
- Base Curve
  - +/- 0.75D
- Impact Resistance
  - 5/8" (15.9mm) steel ball weighing .56 oz (16g) dropped from a height of 50" (127cm), keep record 3 years

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ANSI Z80.1

- Vertical Prism
  - 1/3 ^ or 1mm difference – each eye
- Horizontal Prism
  - 2/3 ^ or +/- 2.5mm
- Cylinder Axis Tolerance

- up to 0.25	+/- 14 degrees
0.25 to 0.50	+/- 7 degrees
>0.50 to 0.75	+/- 5 degrees
>0.75 to 1.50	+/- 3 degrees
>1.50	+/- 2 degrees

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