



## Fundamental Optics

- How we see, what we see

[www.EyeSystems.info](http://www.EyeSystems.info)

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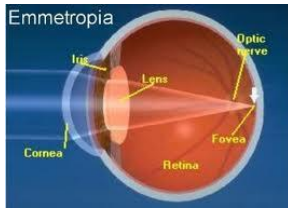
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## Emmetropia

- A "normal" eye visually.
- Ametropia – not emmetropia



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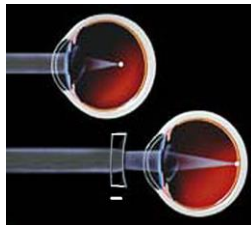
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## Ametropias

### Myopia

- Light rays fall in front of the retina
- The eye is "too long"
- The correct power diverging lens corrects the myopia



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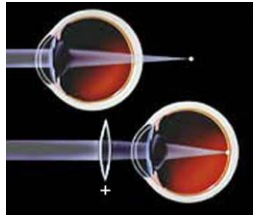
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## Ametropias

### Hyperopia

- Light rays fall behind the retina
- The eye is “too short”
- The correct power converging lens corrects the hyperopia



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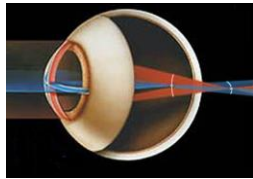
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## Ametropias

### Astigmatism

- The optics of the eye has two powers
- Error may be combined with myopia or hyperopia
- Requires a lens that corrects each power error individually



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## Astigmatism

- Simple – one point on the retina, the other off
  - Hyperopic or Myopic



- Mixed – one point in front, one behind



- Compound – neither focuses on the retina
  - Hyperopic or Myopic



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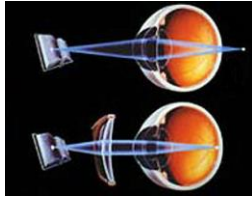
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## Presbyopia

- "Old eye" in Greek
- Loss of accommodation, the ability of the eye to focus at near
- Due to loss of elasticity of the lens



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## Vergence, Distance and Diopters

- The power of a lens is specified in diopters
- A Diopter is the reciprocal of the focal length in meters
- The formula looks like this:

$$\frac{1}{f \text{ (m)}} = \mathbf{D} \quad \text{or} \quad 1 \div f \text{ (m)} = \mathbf{D}$$

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## Light & Optics

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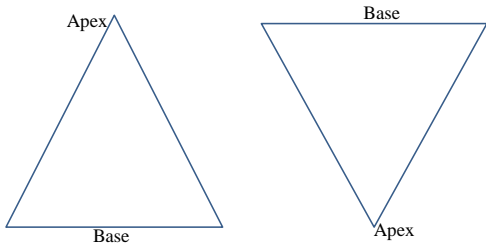
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Prism



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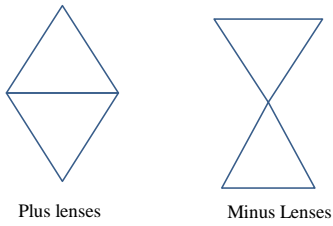
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Prism



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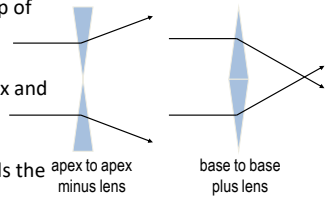
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Imagining a Lens

- Lenses are made up of prisms
- A prism has an apex and a base
- Light bends towards the base, the image towards the apex



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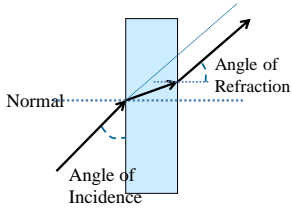
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## Actions of Light

- When light rays strike a surface of a transparent material, they may go straight through or they may be bent. Whether they are bent and how much is dependent upon 3 factors:



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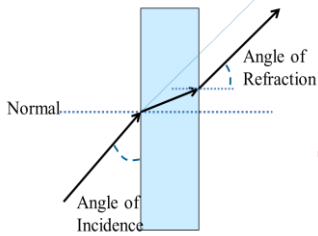
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## Actions of Light



- 1. ANGLE OF INCIDENCE
  - Angle of ray and lens surface
  - If it comes in perfectly perpendicular, it won't be bent

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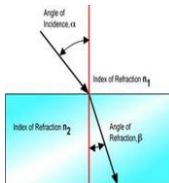
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## Actions of Light

- 2. INDEX OF REFRACTION
  - Light passing through air slows down when it enters a different transparent material. The index of refraction is a number that describes how much the light ray is bent.
  - The higher the index, the more the light ray is bent, the thinner the lens needed to do the job



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## Refractive Index

- Air 1.00
- Crown glass (standard glass) 1.52
- CR-39 (standard plastic) 1.50
- Trivex - Phoenix 1.53
- Polycarbonate 1.59
- 1.6 High Index 1.60
- 1.66 High Index 1.66

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## Index of Refraction

- Index of refraction is given by:  
Index = Velocity in air ÷ Velocity in material

The higher the index, the more light is slowed and the more it can be bent.

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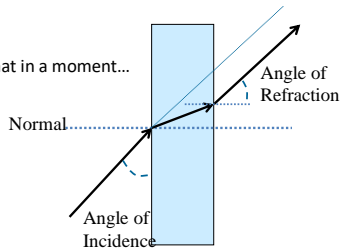
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## Actions of Light

- 3. Lens Shape
  - Let's talk about that in a moment...



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## Spherical Lens Forms

- A spherical surface has the same roundness over the entire surface
- Spherical lenses are sections cut from a sphere



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## Spherical Lens Forms

- Plano
  - No power, front and back surfaces are parallel or curved identically
- Concave
  - Thinner in the center, thicker at the edges
  - Diverge light
  - Minify objects
- Convex
  - Thicker in the center, thinner at the edges
  - Converge light
  - Magnify objects

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## Cylindrical Lens Forms

- A cylindrical surface is that of a torus, a section from a tire or a donut
  - The two different curves are 90° from each other
- Toric surfaces are used in lenses to create two different powers



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## Cylindrical Lens Forms

- Plano cylinder lens
  - A lens with two powers, one being plano or zero power
- Sphero-cylinder lens
  - A lens with two different powers
  - Corrects for astigmatism
- Oriented at angles from 1° to 180°

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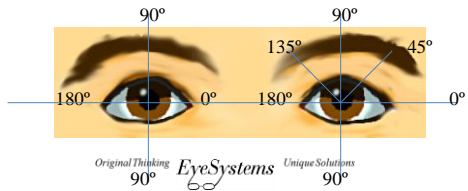
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## Axis Notation

- Cylinder axis is written for axes 1° to 180°
- Only the top half of the axes are used
- Axes are referred to as meridians



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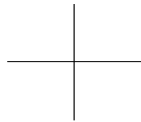
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## Optical Crosses



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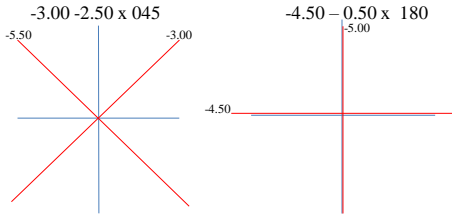
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# Optical Crosses

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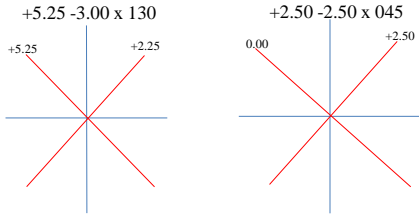
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# Optical Crosses

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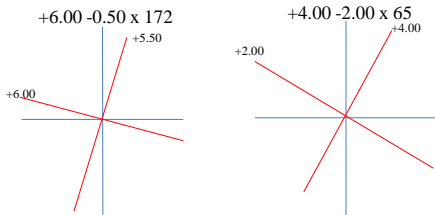
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# Optical Crosses

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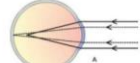
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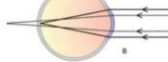
## Astigmatism Types

- Simple Myopic
  - One point on the retina – one off in front



Simple myopic astigmatism

- Simple Hyperopic
  - one point on the retina – one off in back



Simple hypermetropic astigmatism

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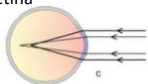
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## Astigmatism Types

- Compound Myopic or Hyperopic

- Both points in front of the retina

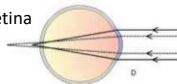
- Myopic



Compound myopic astigmatism

- Both point behind the retina

- Hyperopic



Compound hypermetropic astigmatism

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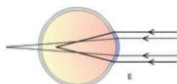
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## Astigmatism Types

- Mixed

- One point in front – one behind the retina



Mixed astigmatism

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Quiz

Prescription

Type of Astigmatism



1. +2.00 -1.00 x 050

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2. -3.00 -6.00 x 080

\_\_\_\_\_

3. +4.25 -3.00 x 130

\_\_\_\_\_

4. +1.00 - 2.00 x 070

\_\_\_\_\_

5. +2.50 -2.50 x 045

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Quiz

6. Index of refraction of Polycarbonate \_\_\_\_\_

7. Describe a spherical lens form:  
\_\_\_\_\_

8. A concave lens \_\_\_\_\_ light rays.

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Answers

- 1.
- 2.
- 3.
- 4.
- 5.
- 6.
- 7.
- 8.

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## What's not clear?

- Questions...
- One step at a time.



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