Prism and Characteristics of Lenses

By

Diane F. Drake, LDO, ABOM, NCLEM, FNAO

Course Description

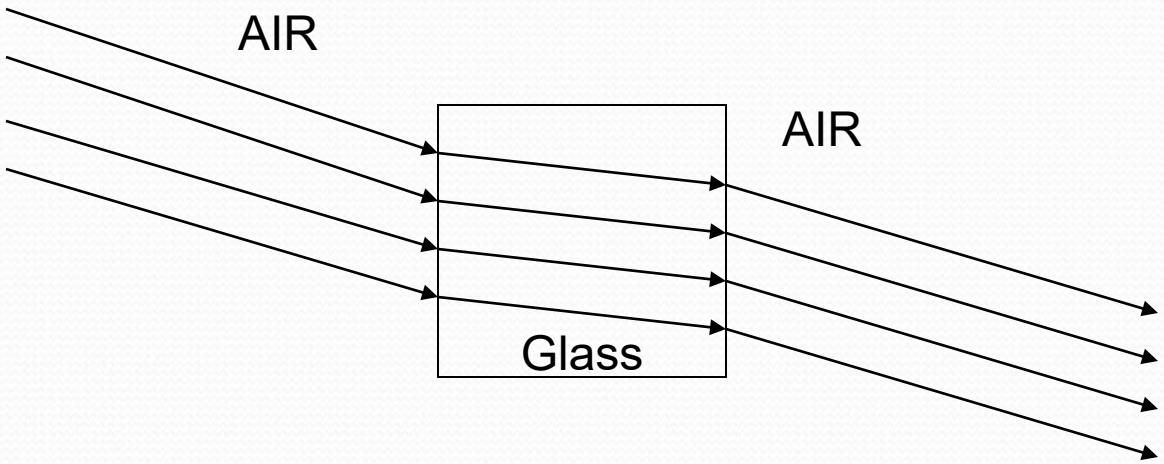
- This course will explain how to identify the characteristics of a lens. Included will be plus lenses, minus lenses, prism and focal length.

Learning objectives/outcomes

- At the completion of this course, the participant will be able to:
  - Understand the characteristics of a lens
  - Understand prism
  - Identify characteristics of a plus lens
  - Identify characteristics of a minus lens

Refraction

- If the light strikes the surface at an oblique angle, it will be slowed down, bent, and will emerge slightly deviated from its original path

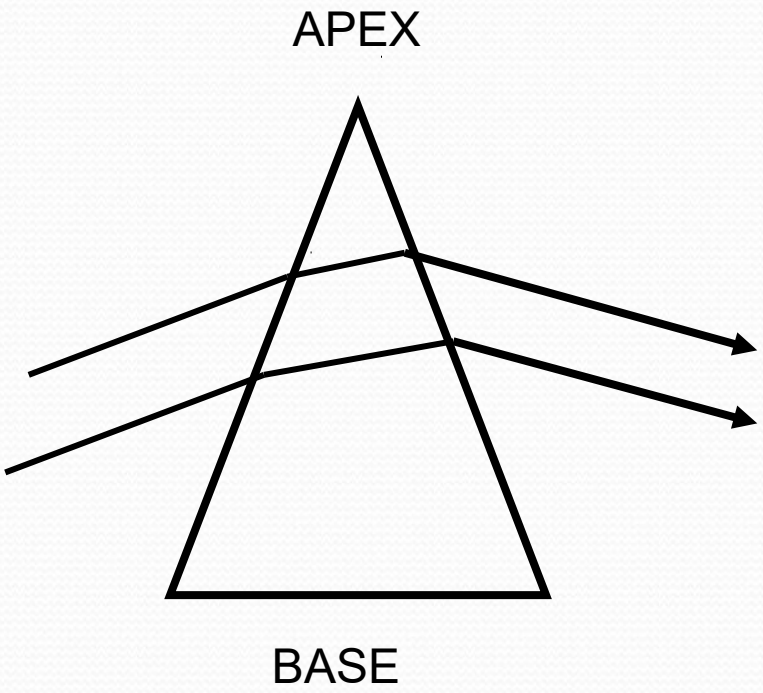


Characteristics of Prisms

- Lenses are prisms
  - What are prisms?
  - A prism is a wedge shaped piece of optical medium with a base and an apex connected by two sides which are not parallel
    - Apex is point at top
    - Base is flat surface on which it rests
    - Two sides slant inward from the base to the apex
  - The symbol used to designate prism is the triangle (Greek Delta Symbol Δ)

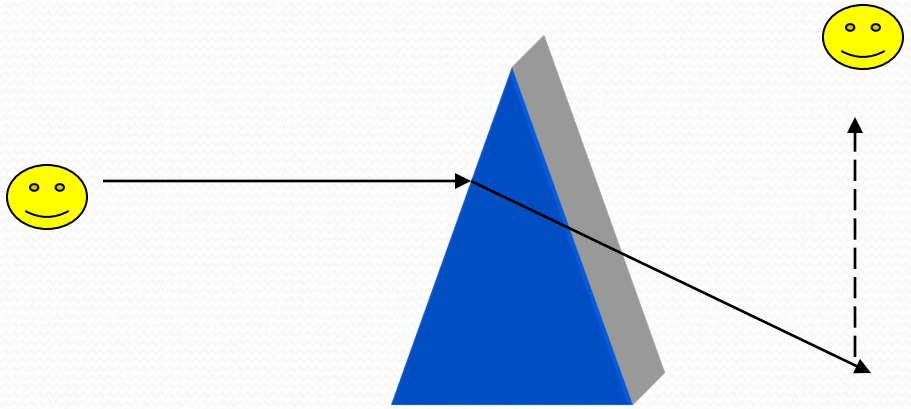
Characteristics of Prisms

- Prisms
  - Light passing through a prism is bent toward the base
  - The image is displaced toward the apex



Prism

- Light strikes a prism
  - light ray is bent (deviated) toward the base
  - image is displaced toward the apex.

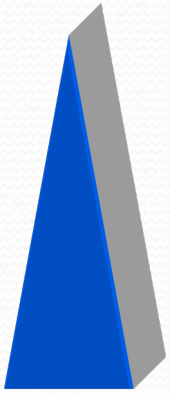


Prism

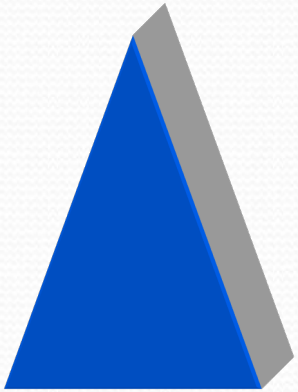
- Power of prism is referred to as prism diopter
  - 1 Δ will deviate light 1 cm at 1 M
  - 2 Δ will deviate light 2 cm at 1 M
  - 3 Δ will deviate light 3 cm at 1 M

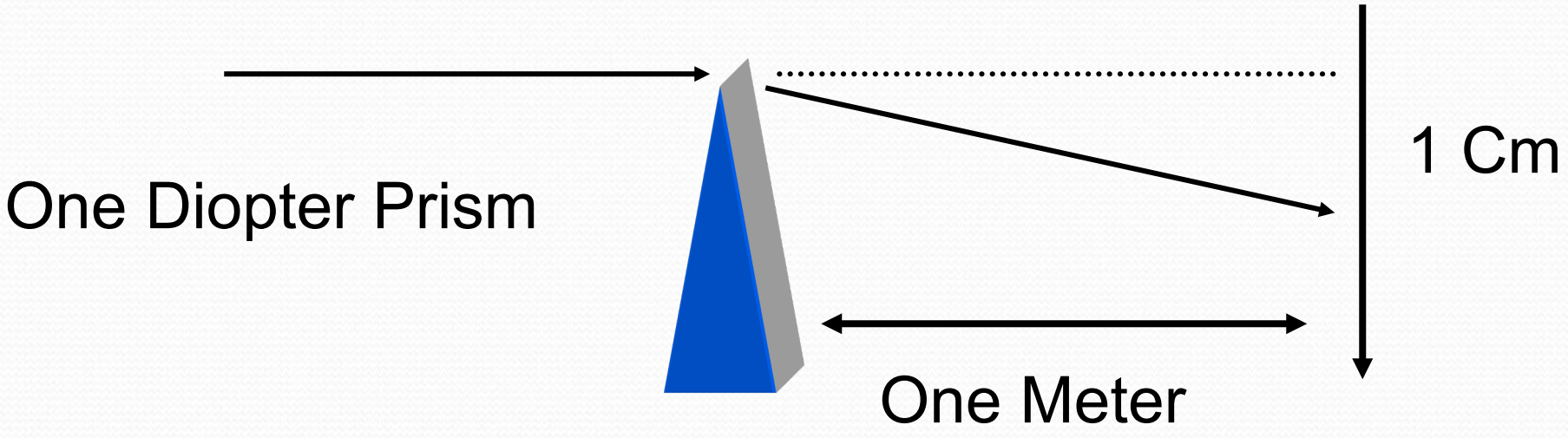
Power of a Prism

Weak Prism



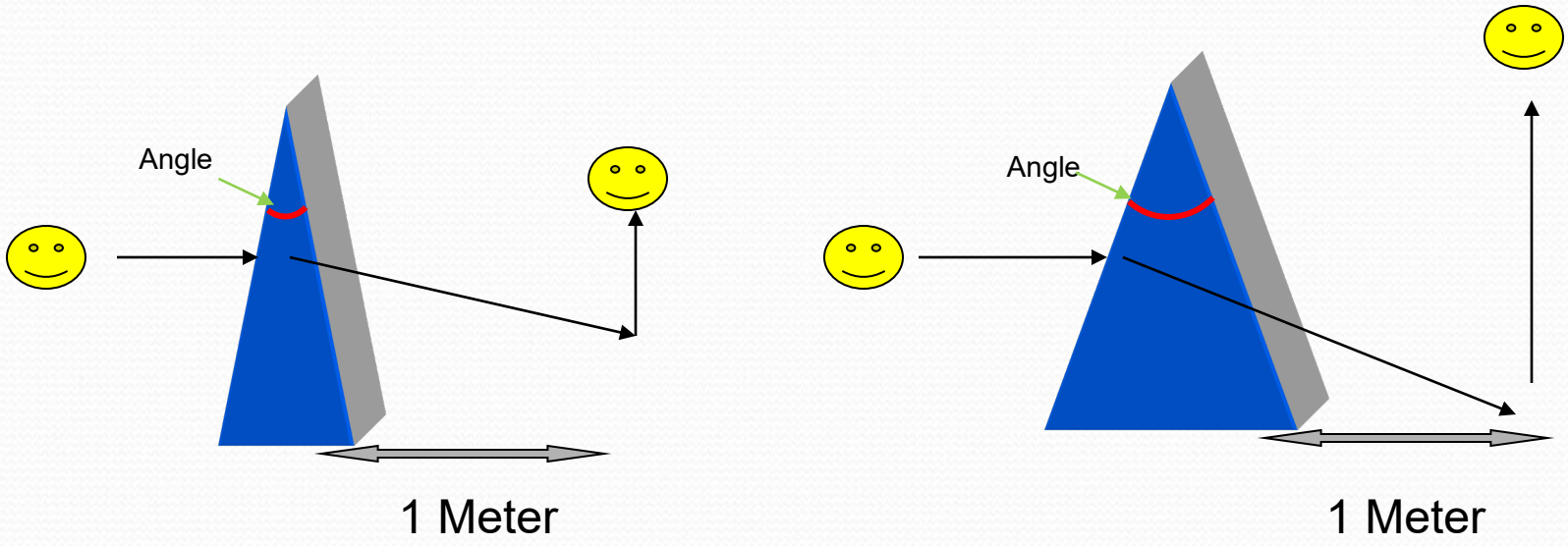
Strong Prism



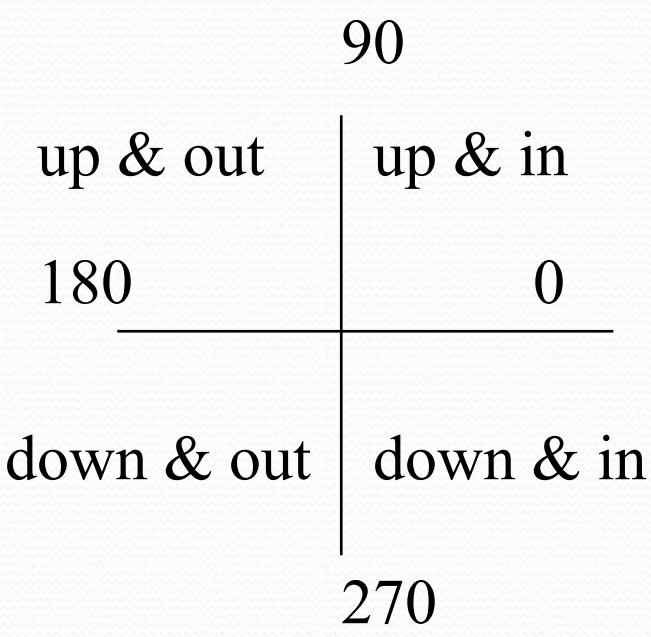


Prism

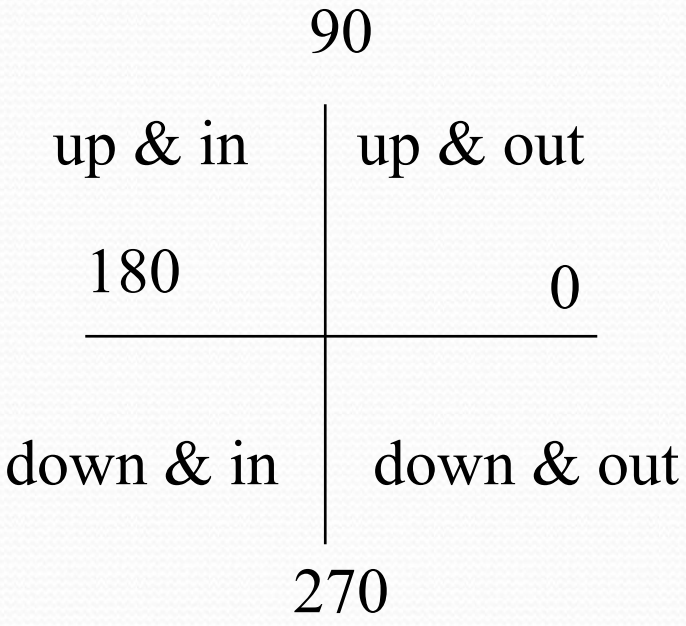
- The greater the difference in thickness between the base and the apex
  - Stronger the power of the prism



Methods of Denoting Prism



Right eye



Left Eye

Time for a Question

How far will 5 prism diopters deviate light at 1 M?

a) 5 mm
b) 0.50 mm
c) 5 cm
d) 0.50 cm

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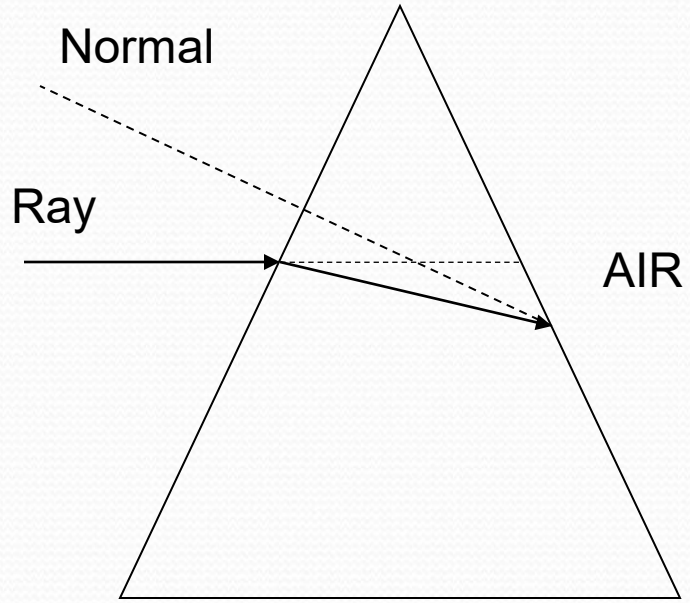
Characteristics of prisms/lenses

- Light passing from a medium of lesser density, such as air, to a medium of greater density, such as glass
  - The path of the light is bent toward the normal



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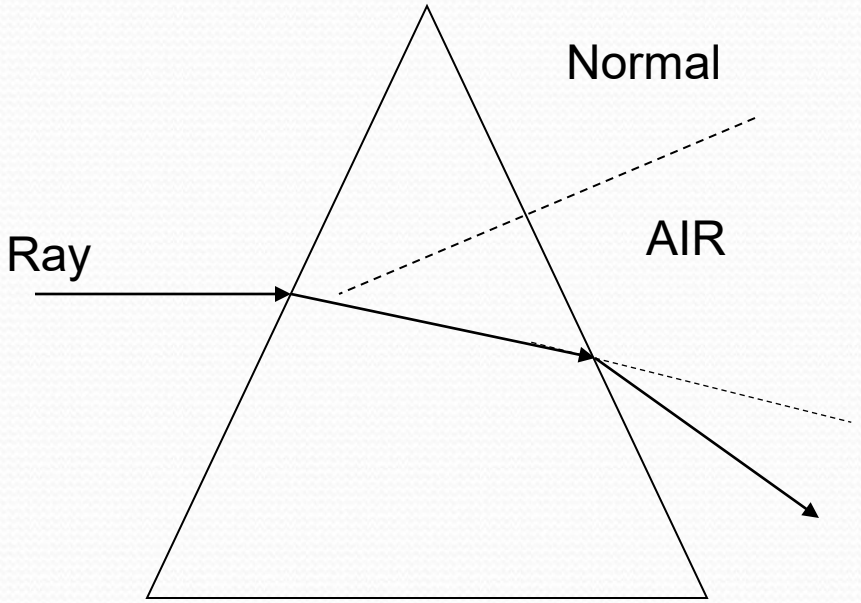
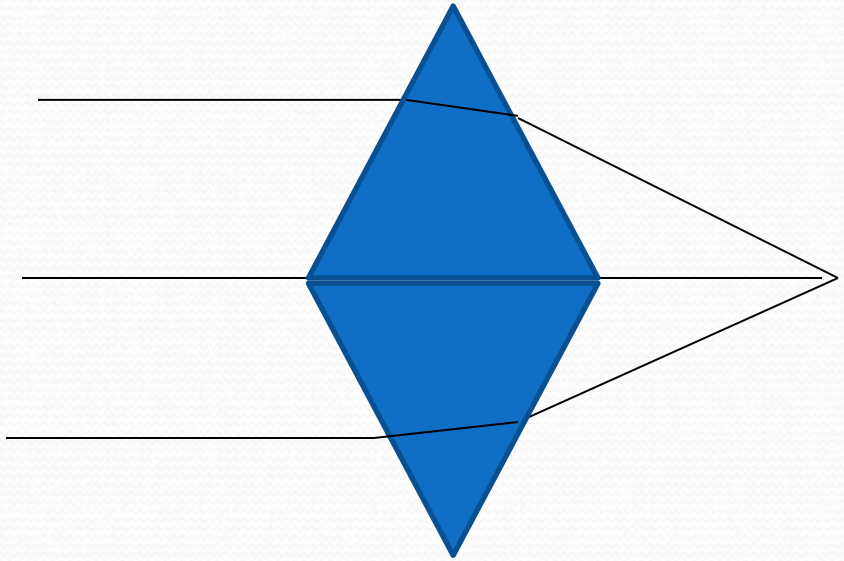


Characteristics of Plus Lenses

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



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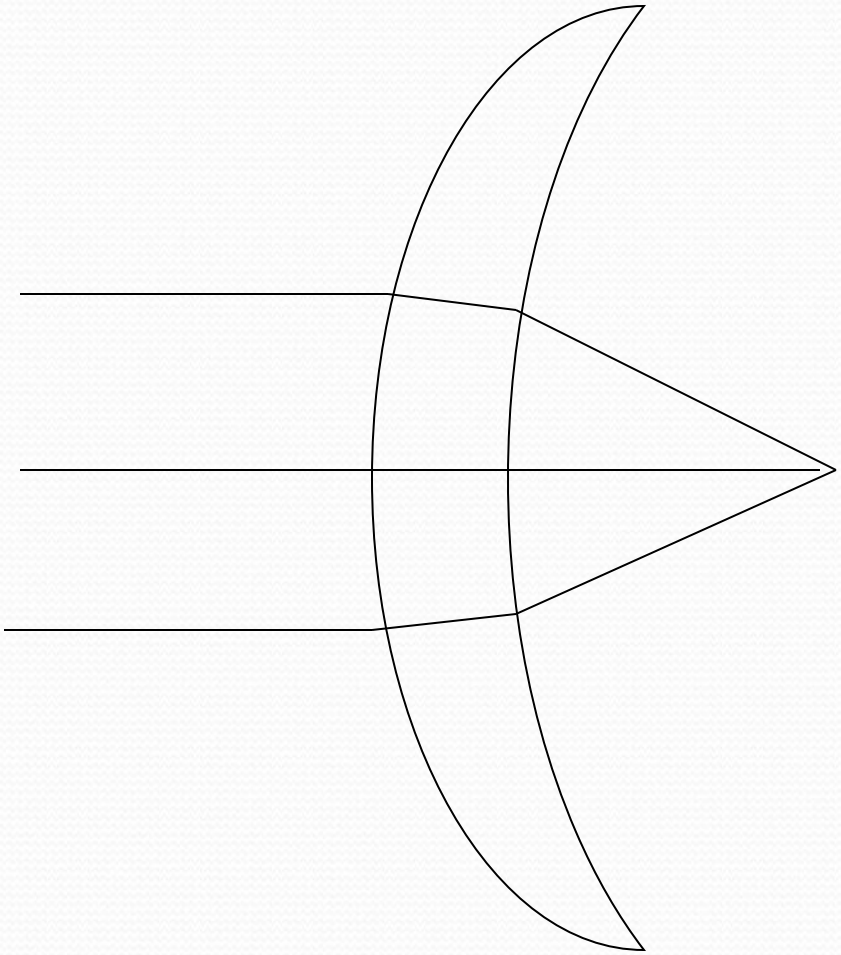

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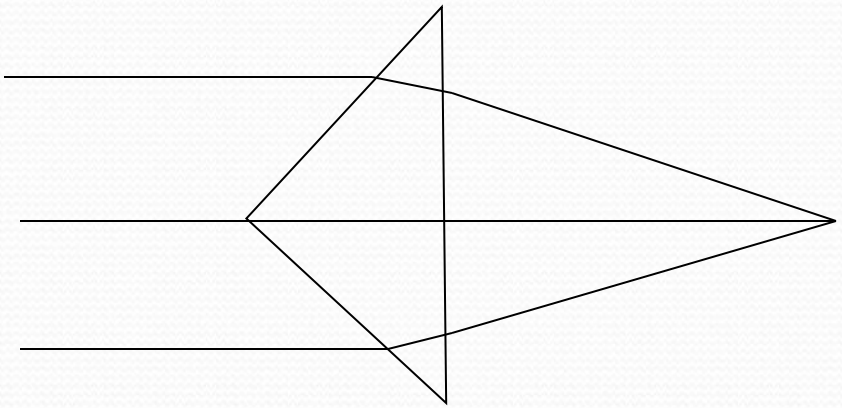
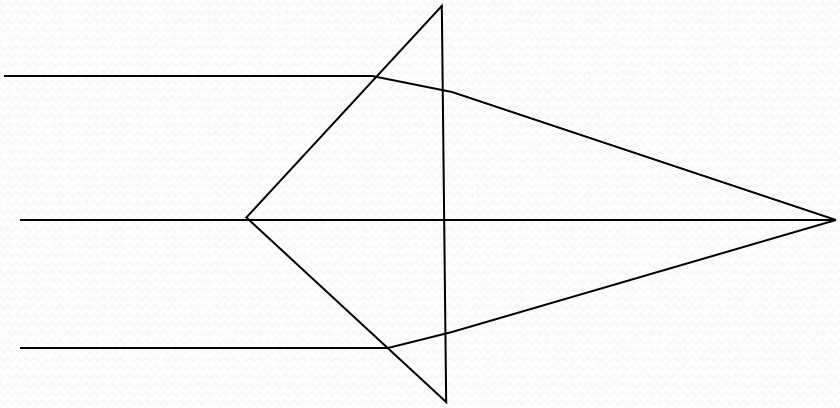


Characteristics of Plus Lenses

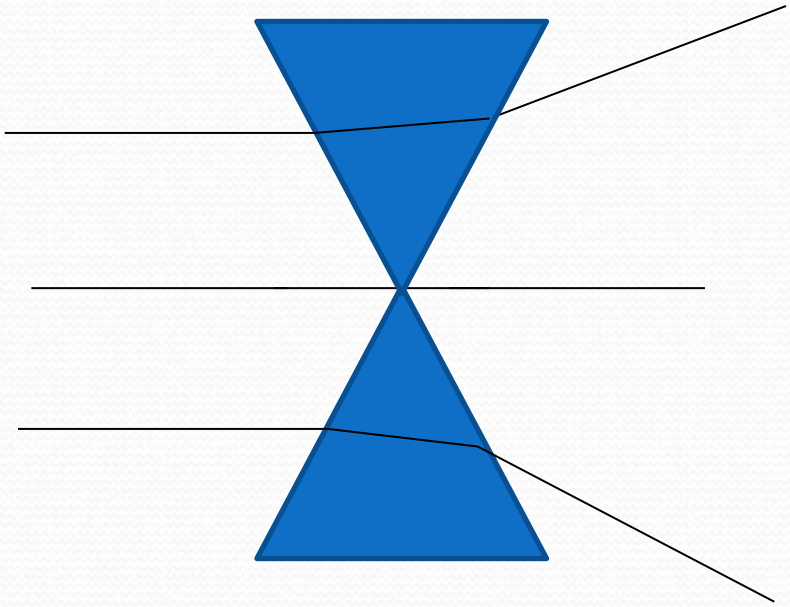
- Light is bent toward the base (middle of the lens) and the image is displaced toward the apex. Creates against motion



Lens moves down, image moves up

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



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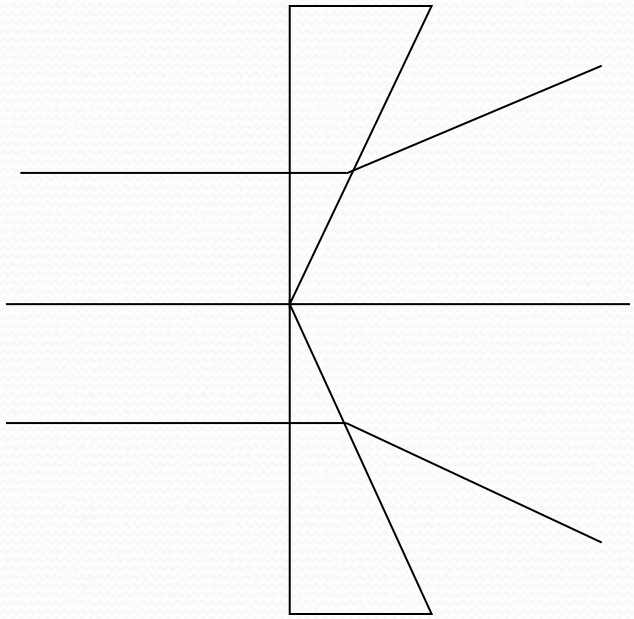

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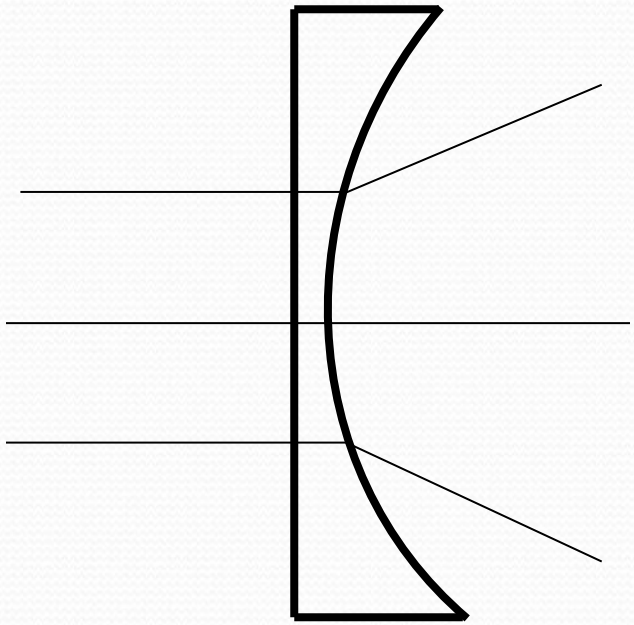
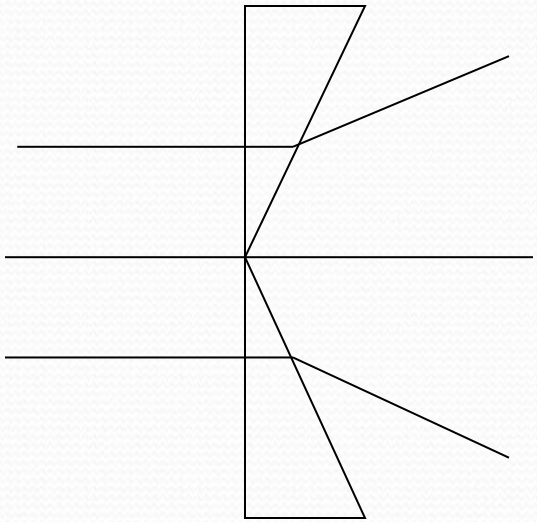


Characteristics of Minus Lenses

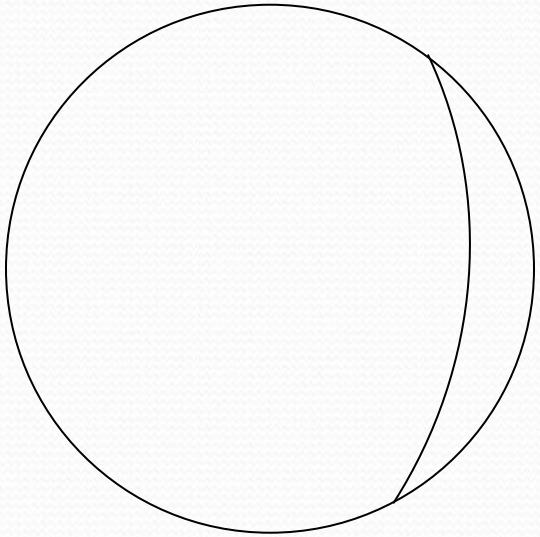
- Light is bent toward the base (edge of the lens) and the image is toward the apex or center of the lens. Creates with motion

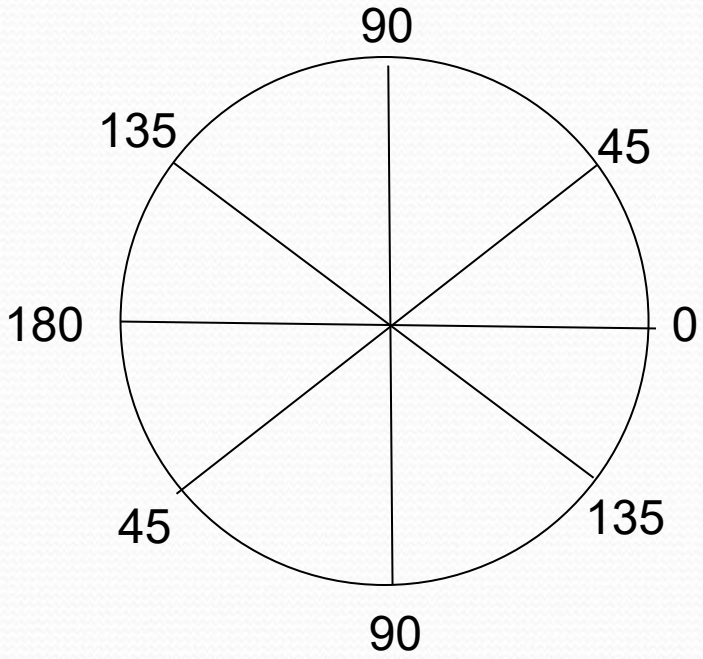


Lens moves down,
Image moves down

Characteristic of Sphere Lenses

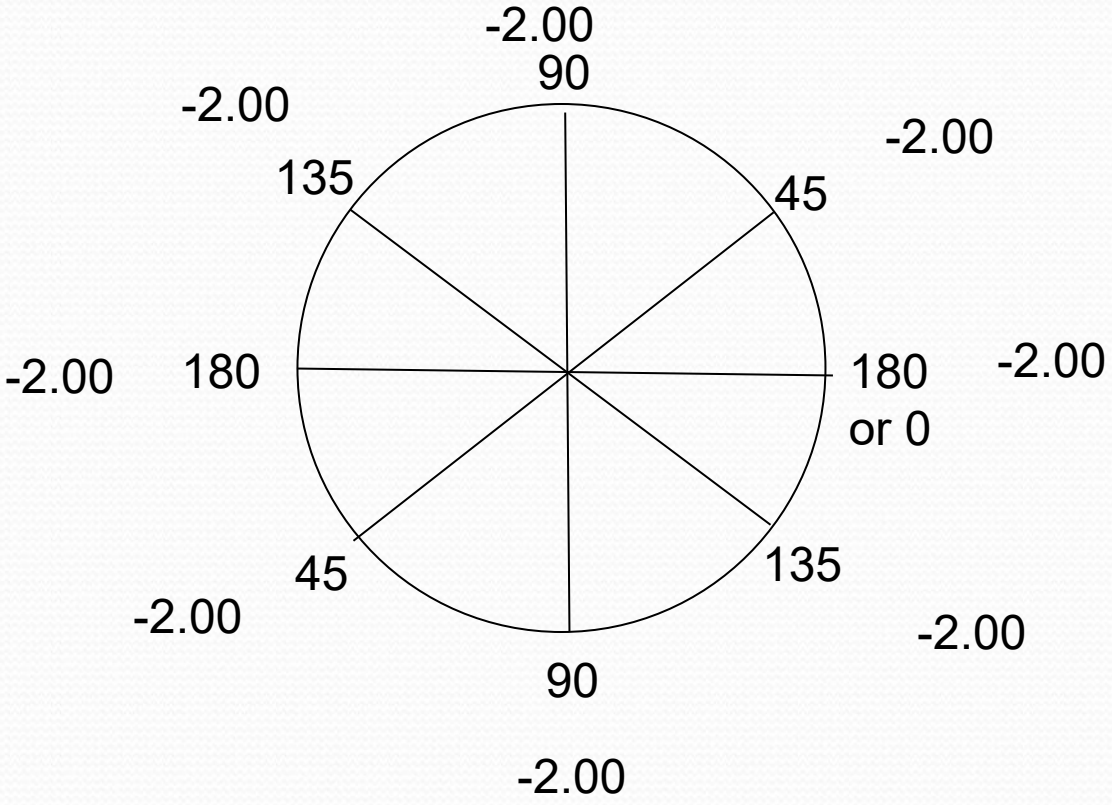
- The sphere power of a lens is the same throughout the lens





Characteristic of Sphere Lenses

- The sphere power of a lens is the same throughout the lens in every meridian

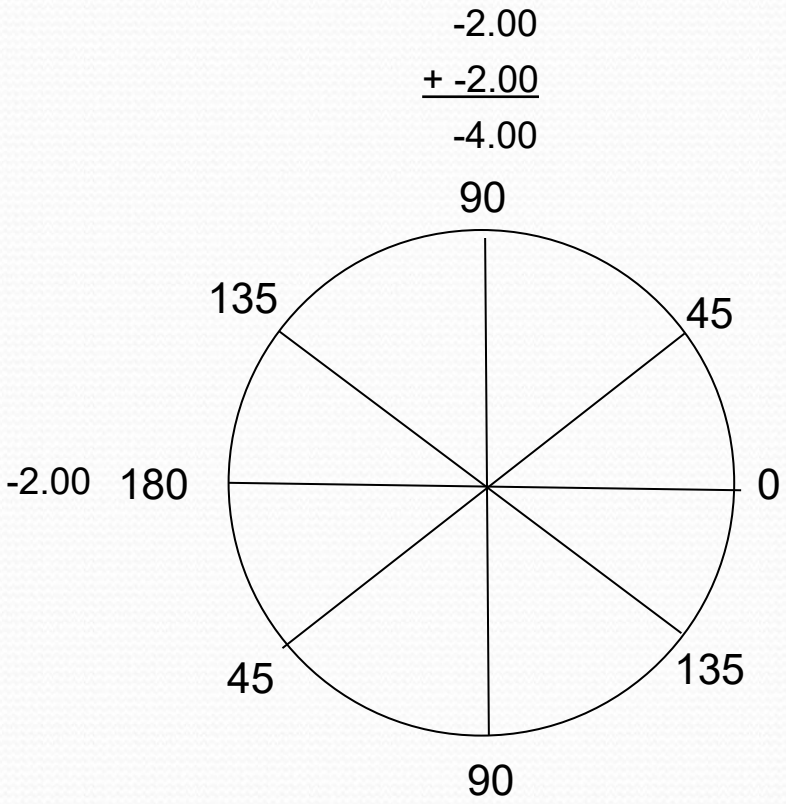


Characteristics of Compound Lenses

- Combine a spherical surface with a toric or cylindrical surface
- Strongest and weakest curves are 90 degrees apart
- Plus cylinder form has cylinder on the front
- Minus cylinder form has cylinder on the back
- Axis represents zero cylinder power

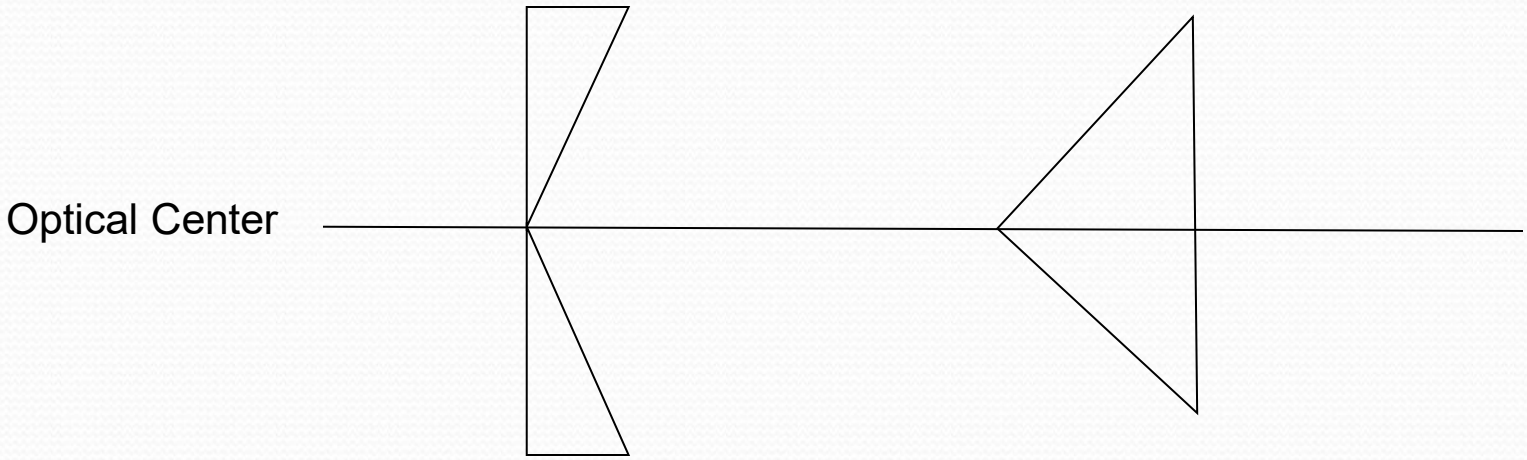
Characteristics of Compound Lenses

- Compound lenses have varying thickness throughout the lens
- The sphere power is that point on a lens with no cylinder power
  - 2.00 – 2.00 X 180
  - Full cylinder power is 90 degrees away from the axis and is added to the sphere power



Optical Center

- The optical center of a lens is that singular point which light may pass through without being deviated. The point of no prism in a lens. In a minus lens, it the point where the two prisms meet apex to apex. In a plus lens, it is the point where the two prisms meet base to base.



Time for a Question

Some characteristics of plus lenses include:

a) Magnifies images, converge images, power weakens as vertex shortens
b) Minifies images, diverges images, power strengthens as vertex shortens
c) Magnify images, diverges images, power strengthens as vertex shortens
d) Minifies images, diverges images, power weakens as vertex shortens

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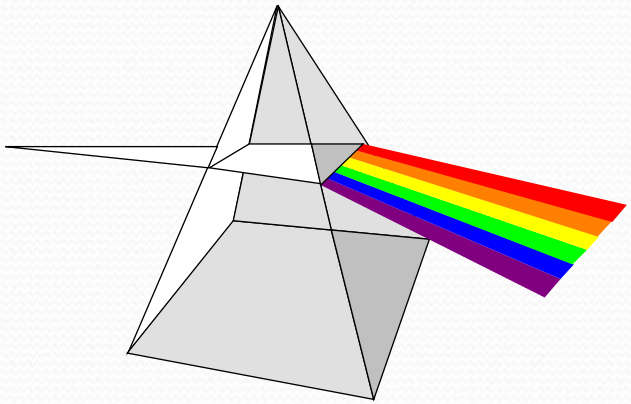
Factors Affecting Lenses

- Index of Refraction
  - How much does it bend light?
- Abbe Value
  - What are the optical properties of the material?
- Specific Gravity
  - What are the lenses going to weigh?
- Impact Resistance
  - How safe are these lenses?

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

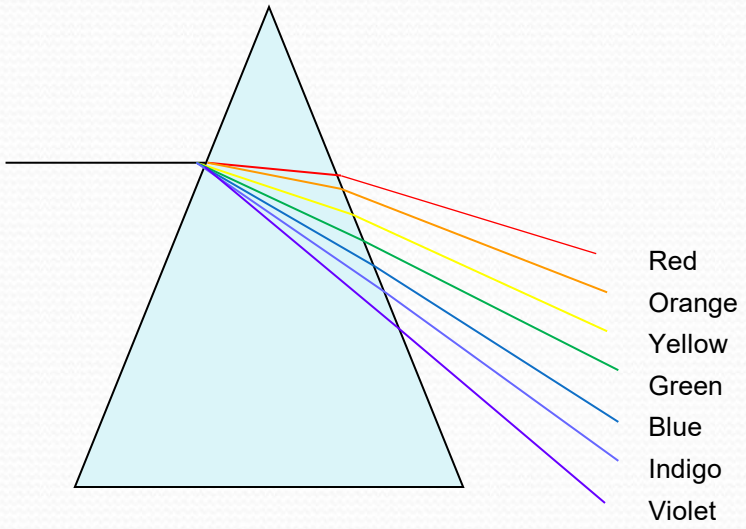


Dispersion

- 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

Dispersion

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



Classifying Lens Materials

- Most ECPs recognize four material index categories—low, mid, high, and ultra-high. There is no official standard that subdivides these materials, but the optical industry generally follows this breakdown:

  - Low index: <1.53
  - Mid index: 1.53 to 1.58
  - High index: 1.59 to 1.66
  - Ultra-high or super-high index: >1.66

Index of Refraction

- Speed of light through a medium as compared to speed of light in air

- Speed of light through air is 186,000 miles per second

Index of Refraction

- Formula is:
  - $n = S^1 / S^2$
- Where
  - n = index of refraction
  - S^1= speed of light in air
  - S^2 = speed of light in another medium

- Example
  - n = 186,000/124,832
  - n = 1.49 (CR39)

Another way to write formula

$$n = \frac{\text{speed of light in air}}{\text{speed of light in the medium}}$$

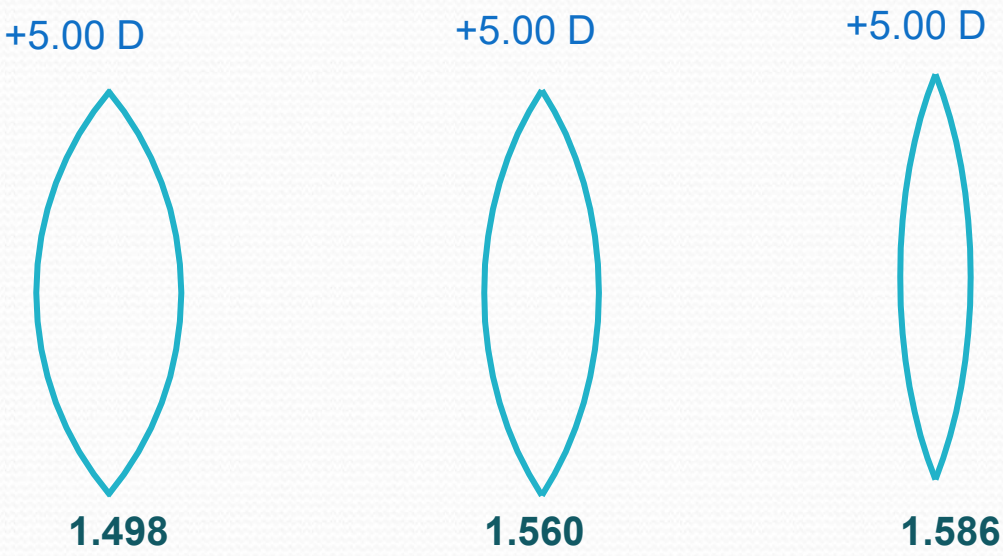
Index Of Refraction

$$\frac{\text{speed of light in air}}{\text{speed of light in medium}}$$

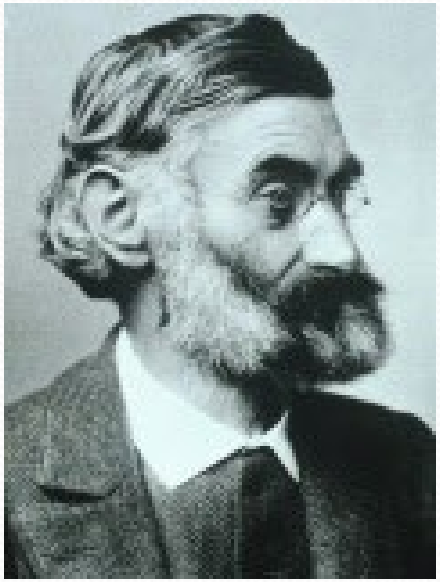
Material	Index of Refraction
Air	1.00
Ice	1.31
Water	1.33
Diamond	2.41

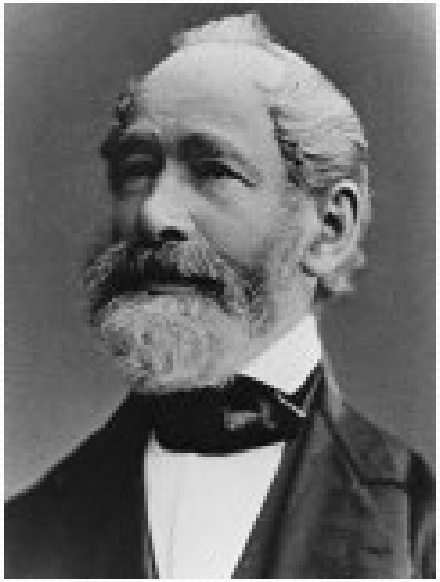
Higher Index Means Thinner Lenses

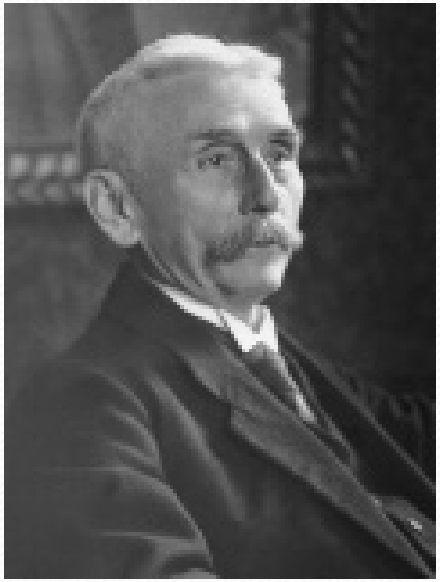
- As the index of refraction goes higher, a lens of a given prescription and diameter needs less curvature and thickness to produce that power.
- For plus lenses, this translates into thinner centers; for minus, it means thinner edges.



ABBE VALUE







- Ernest Abbe working with Carl Zeiss and Otto Schott developed a mathematical formula to determine the amount of chromatic aberration a lens material will produce.

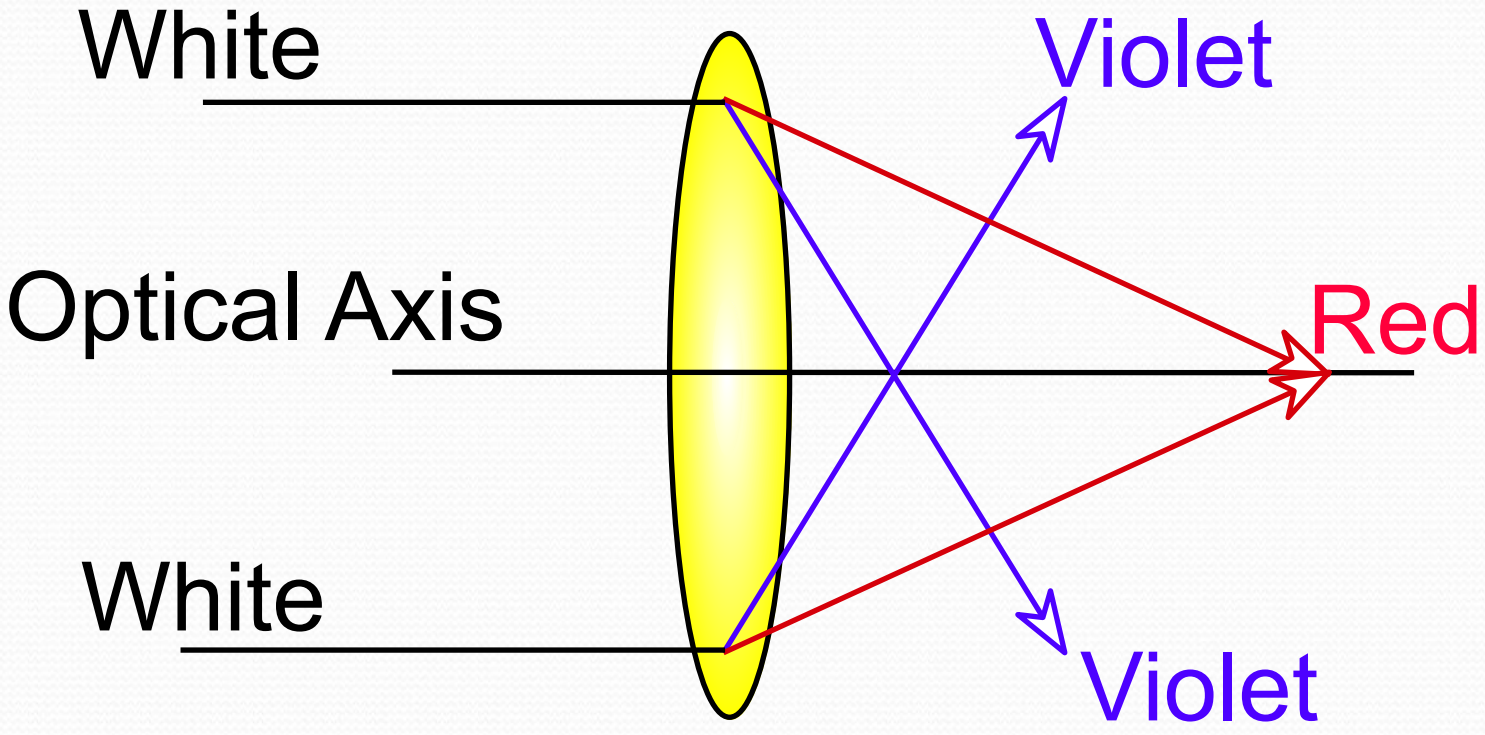
- The higher the abbe value the less the chromatic aberration

ABBE VALUE

- The measure of a material's characteristic of breaking light into its component colors
- 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

Chromatic Aberration

The index of refraction of a material varies with wavelength, different wavelengths of light are focused at different focal points by a lens.



Chromatic Aberration

A normal lens suffers from chromatic aberration because short wavelengths bend more than long wavelengths.

Specific Gravity

- The specific gravity of a substance is a comparison of its density to that of water

Specific Gravity

weight of a given volume of a substance

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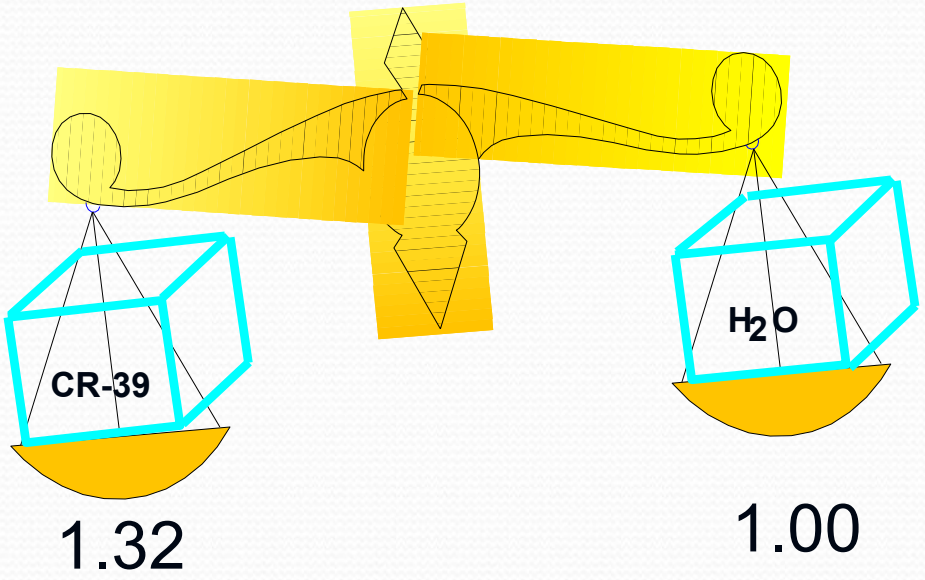
weight of equal volume of water



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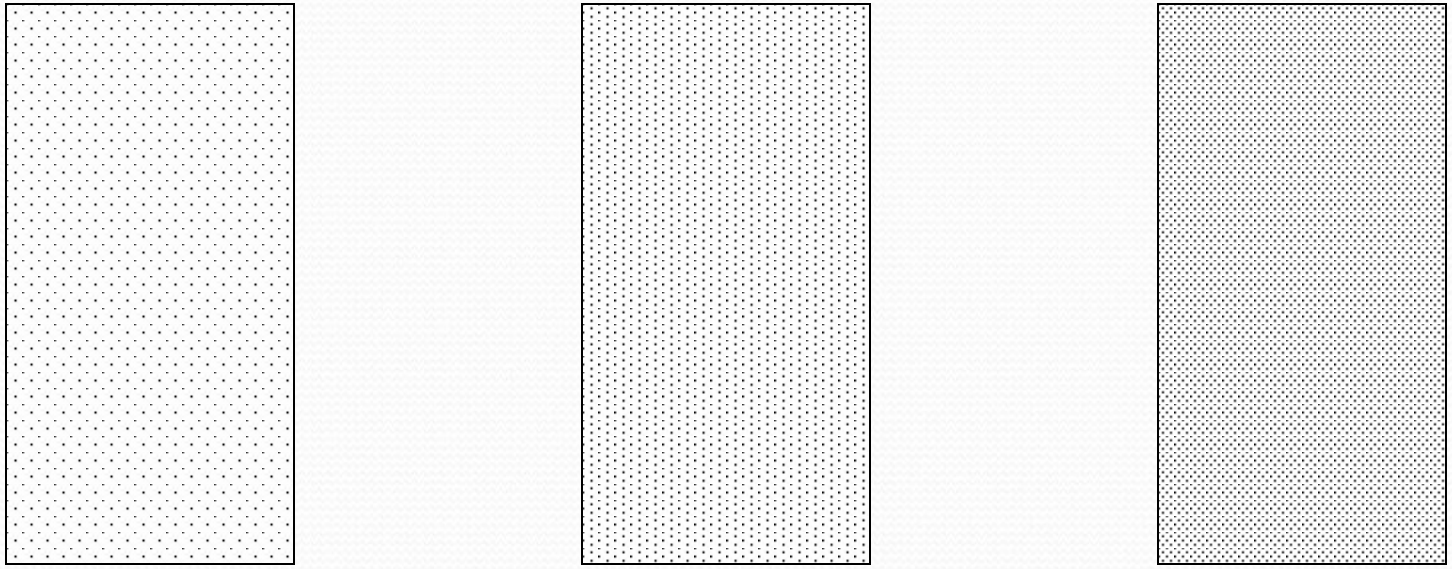


Specific Gravity

- Weights of high index materials vary considerably, with glass products leading the list as the heaviest.
- Thinner doesn't necessarily mean lighter weight. Some high index products have a higher specific gravity than others.
- An aspheric lens design is a good way to make lenses thinner, which also makes them lighter.

Lens Material Properties

Material	Index	Specific Gravity (g/cm3)	Abbe	Reflectance	Transmittance UVA (286 – 320 nm)	Transmittance UVB (320 – 380 nm)
Crown Glass	1.52	2.54	59	4.3	84.3	30.5
CR-39	1.50	1.32	58	4.0	10.3	0.0
Trivex	1.53	1.11	43 - 46	4.4	0.0	0.0
Poly	1.58	1.21	29 - ***32***	5.2	0.0	0.0
1.60 (MR6)	1.60	1.22	42	5.3	0.0	0.0
1.60 Glass	1.60	2.60	42	5.3	39.1	0.1
1.66 (MR7)	1.66	1.35	32	6.2	0.0	0.0
1.67	1.67	1.35	32	6.2	0.0	0.0
1.70 Glass	1.71	3.20	35	6.7	24.6	0.0
1.80 Glass	1.81	3.66	25	8.2	19.5	0.0

Impact Resistance

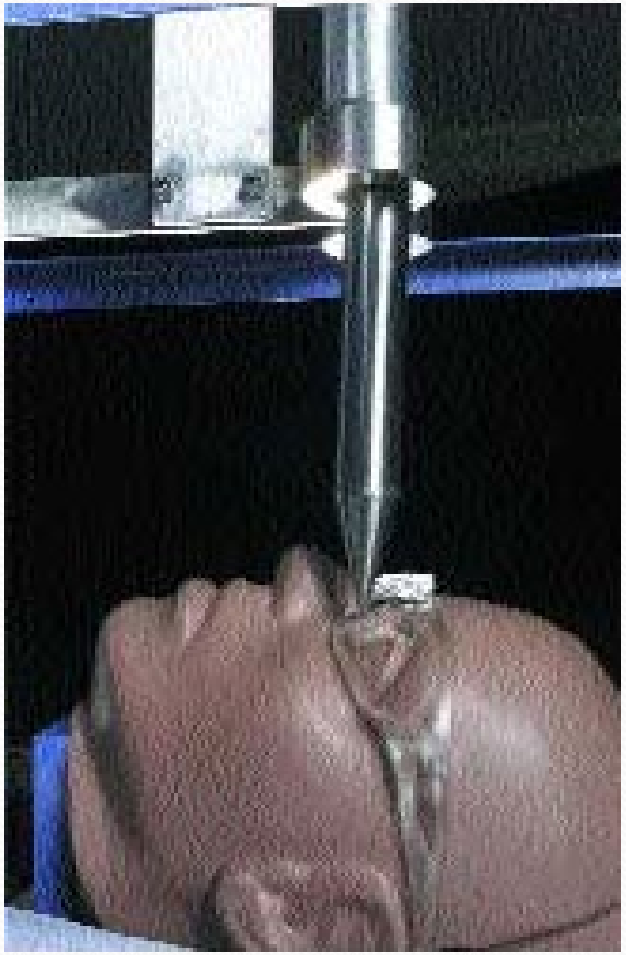
- Safety is a major concern
- Dress ophthalmic lenses used to have to be 2.0 mm thick – no longer
  - Standard drop ball testing
    - 5/8 inch steel ball (.56 oz.) dropped from 50 inches
- Most materials offer impact resistance higher than CR-39. Polycarbonate and Trivex lenses pass the ANSI Z87.1(safety eyewear) Impact resistance testing.

High Velocity Impact Test

- A 6.35mm (1/4 in.) steel ball traveling at 150 ft/s or approximately 103 mph.
- No contact with the eye of the head form is allowed.
- No piece shall be detached from the inner surface of any spectacle component.
- The lens shall be retained in the frame.

High Mass Impact Test

- A 500g (17.6 oz.) pointed projectile dropped from a height of 127cm (50 in.)
- No piece shall be detached from the inner surface of any spectacle component.
- The lens shall be retained in the frame.



Conclusion/Questions/Answers

Thank You