Designing and Crafting Strong and Unusual Lenses

Presented By:
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What is a Strong Lens ?

- Unfortunately, although strong lenses are mentioned in A.N.S.I., there is no clear definition of them.

- I generally consider a lens to be “strong” when the power in at least one principle meridian is (+ or -) 4.00 Diopters or more.

Vergence Power

- The ability of an optical system to change the convergence or divergence of light.
- Quantified by the reciprocal of the focal length (expressed in meters)

$$D = \frac{1}{f} \quad \text{or} \quad f = \frac{1}{D}$$

- Expressed as Diopters or fractions thereof.

Factors That Contribute to Lens Power

- 1. Front Curve
- 2. Back Curve
- 3. Thickness
- 4. Index of Refraction
- 5. Vertex Distance (Effective Power)

The Role of the Front (Anterior) Curve

- The Front or Anterior Curve of a lens may be specified in Diopters, or as a Radius of Curvature.
- Surface curvature is measured with a lens clock
- Selection of the base curve plays an important role in lens magnification

Magnification

- The increase in the apparent size of an image in relation to the actual size of the object

- Determined by the Dioptric power, this can be approximated by dividing by 4.

4 Diopters = 1 X magnification

8 Diopters = 2 X magnification

16 Diopters = 4 X magnification

Selection of the Base Curve

- Lens designers select Base Curves to create lenses that provide good optical performance, and that are cosmetically appealing.

Early Attempts at Standardization of Base Curves - Periscopic

- Periscopic Lenses had a Base Curve of 1.25 Diopters
- Good for high minus lenses
- Limited usable lens area in common Rx.'s

Early Attempts at Standardization of Base Curves - Meniscus

- Meniscus Lenses had a Base Curve of 6.00 Diopters
- Good for lenses in common Rx.'s
- Limited usable lens area in high plus or minus

Tscherning's Ellipse

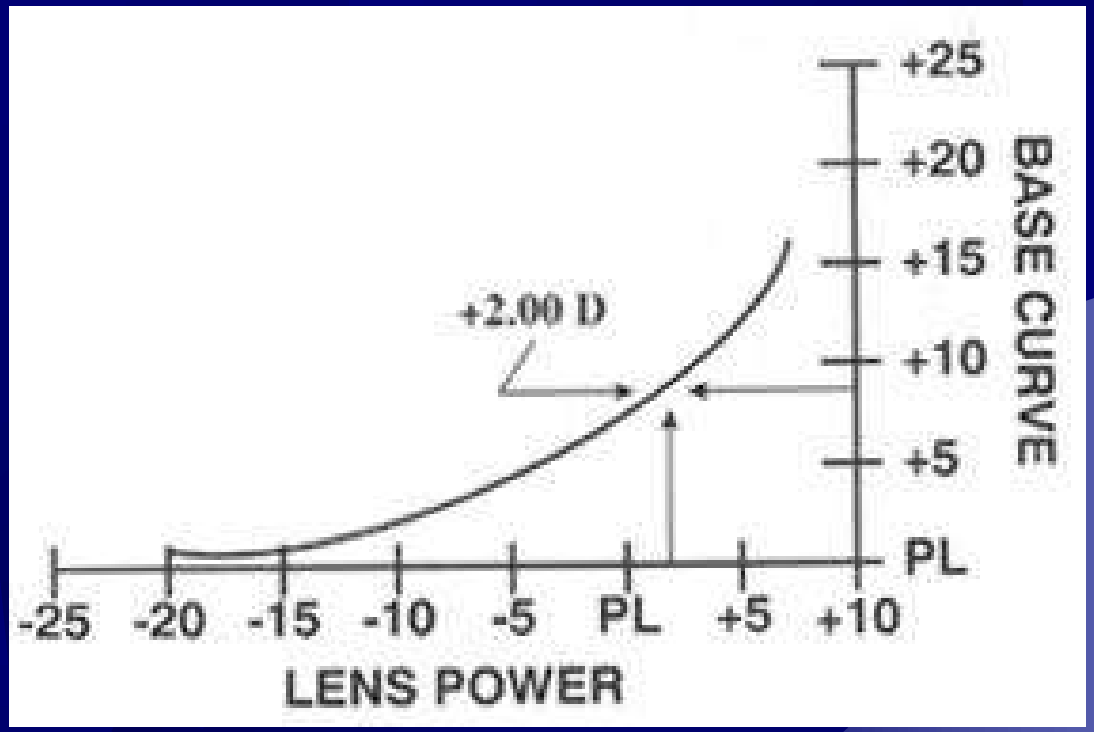
- An elliptically plotted curved line that displays the optimal front (base) curvature of a lens
- Used to minimize the effects of oblique astigmatism aberration.

Best Form (Corrected Curve) Lenses

- Lenses designed to reduce lens aberrations and provide a wide field of view are referred to as ***best form lenses***
- Best form lenses can not eliminate *all* lens aberrations simultaneously
- Best form lenses may be cosmetically less appealing, because they are often steeper and thicker than flatter lens forms

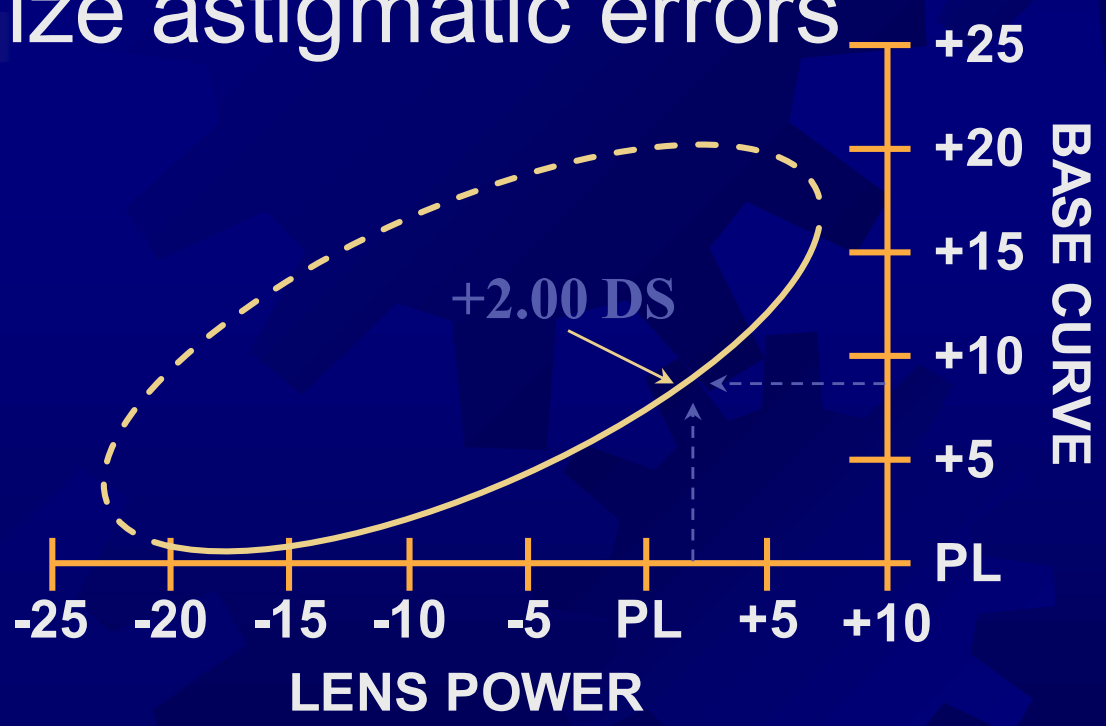
Corrected Curve Lenses

- Base curve varies as power increases
- Uses Tscherning's Ellipse to determine appropriate base curve for each Rx.

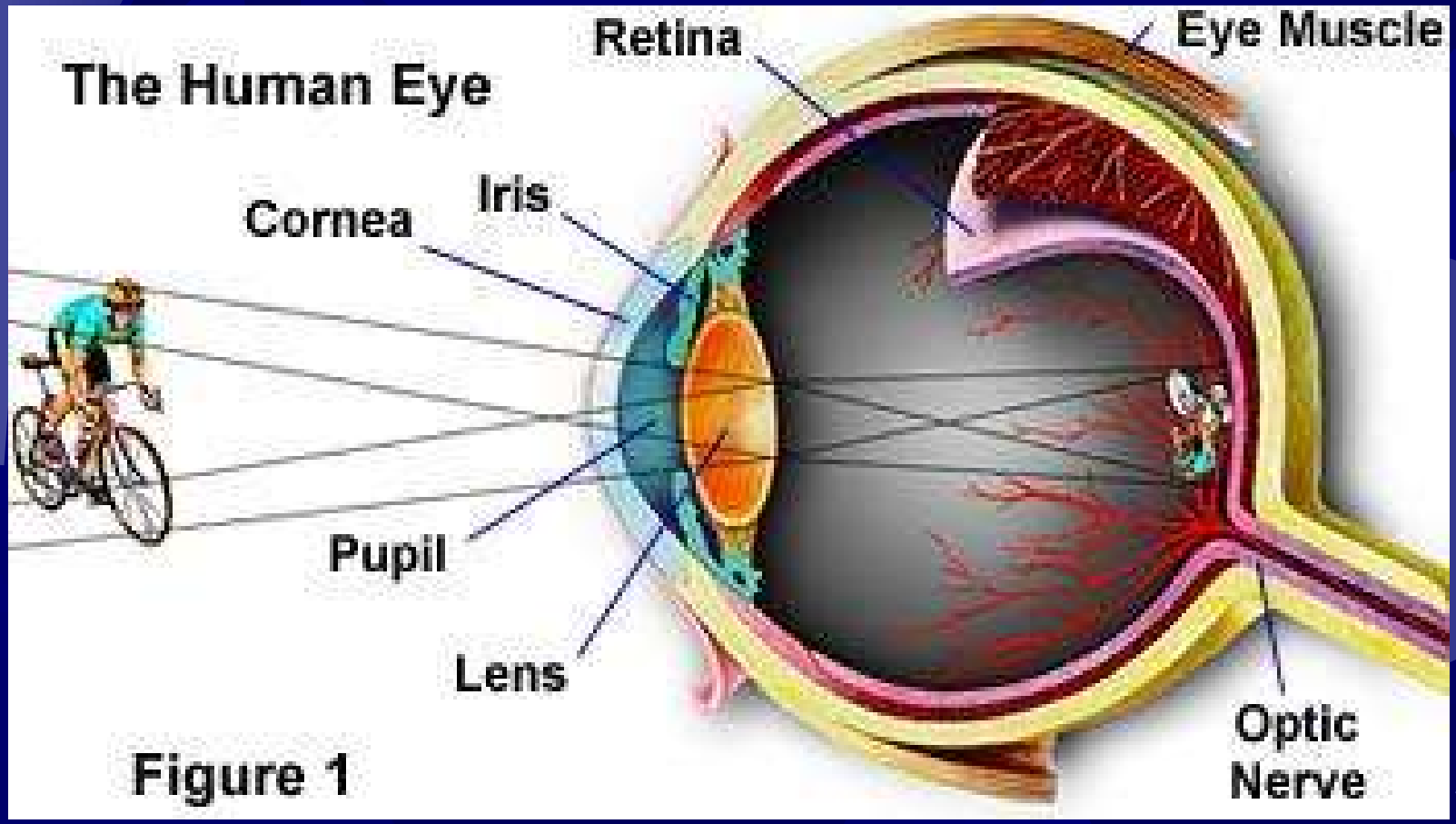


Tscherning's Ellipse

- Each lens power requires a unique ***base*** (front) curve to eliminate or minimize astigmatic errors



Optical Aberrations
Lens Design Factors – They Control How We See

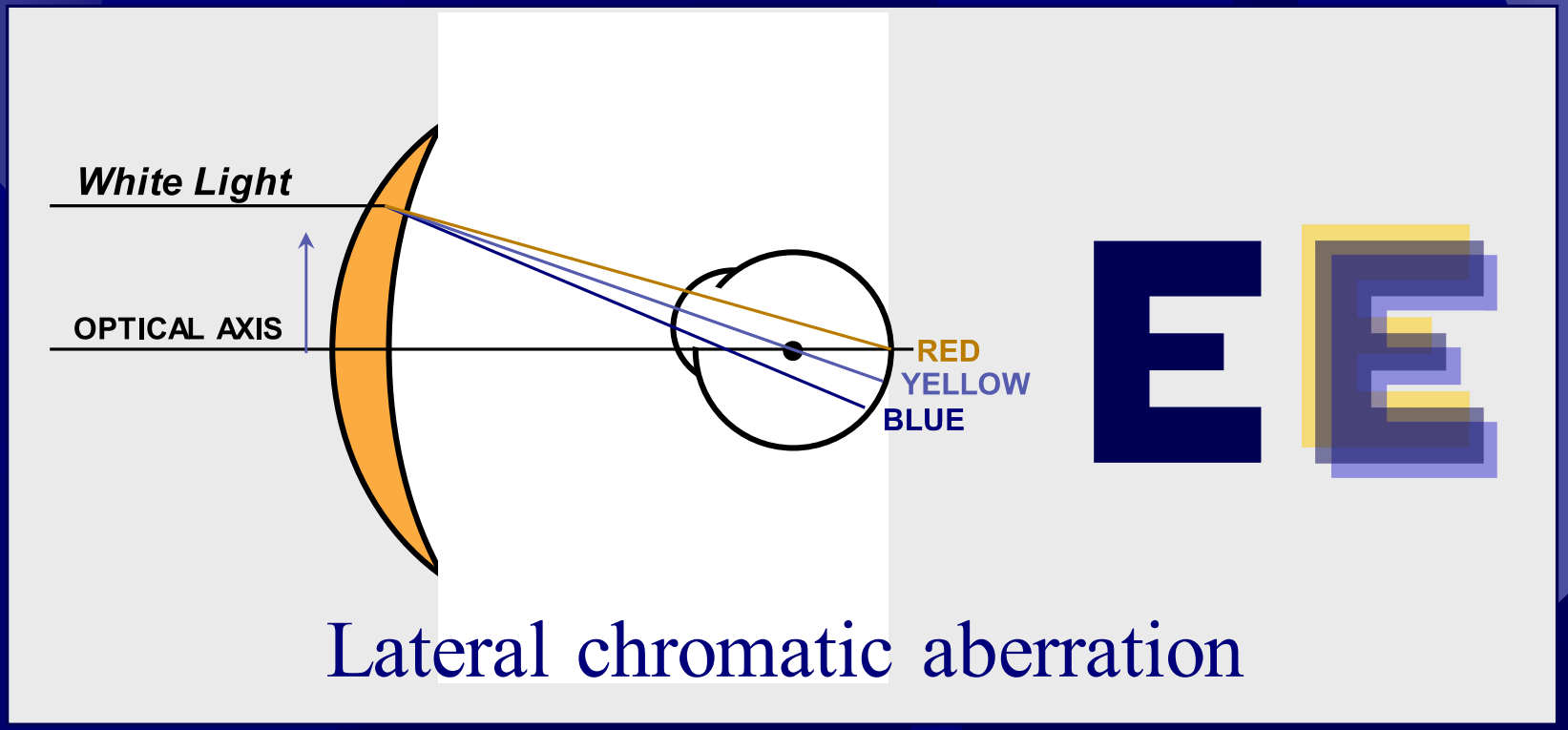


Optical Aberrations in Lenses

- The creation of a blurred or distorted images due to the physical properties of a lens or lens material.
- These aberrations tend to create problems in high powered lenses

Chromatic Aberration

- Proper lens design reduces the intolerance to the chromatic aberration of lenses



Lateral chromatic aberration

Chromatic Aberration

- Unequal refraction of different wavelengths of light
- Abbe value determines the amount of chromatic aberration

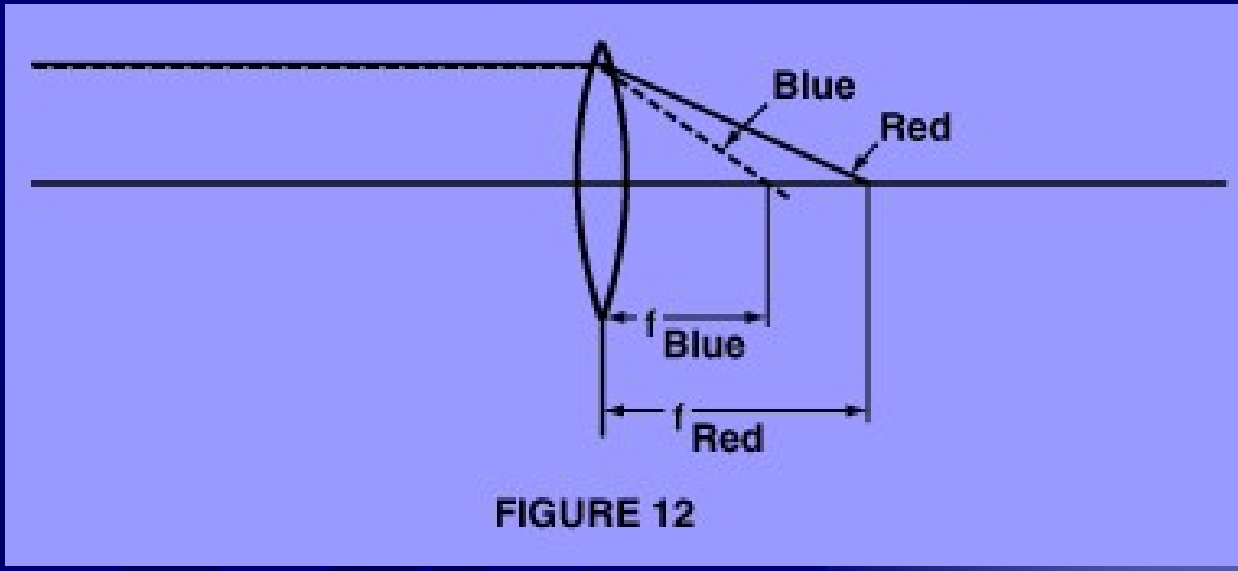
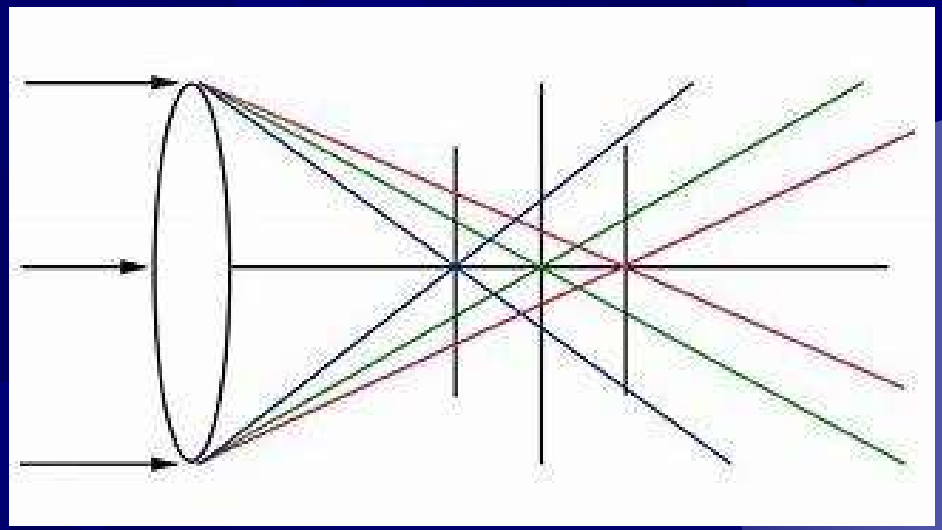


FIGURE 12

Chromatic Aberration

- Tends to be a problem in low Abbe value lenses that are often used in high powers

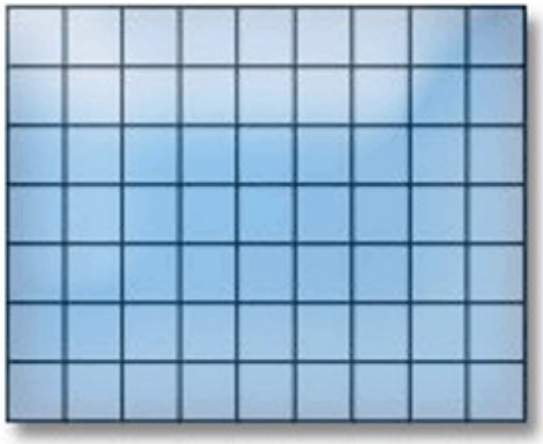


Distortion

- Generally found in high powered lenses
- The majority of people notice this effect with a prescription higher than 4 diopters
- They describe the image as “curved at edges”
- Can be controlled with aspheric lens designs

Distortion

- In ophthalmic optics, "pin-cushion" distortion occurs with plus lenses whereas "barrel" distortion occurs with minus lenses A visual image of the effects of distortion in plus and minus lenses



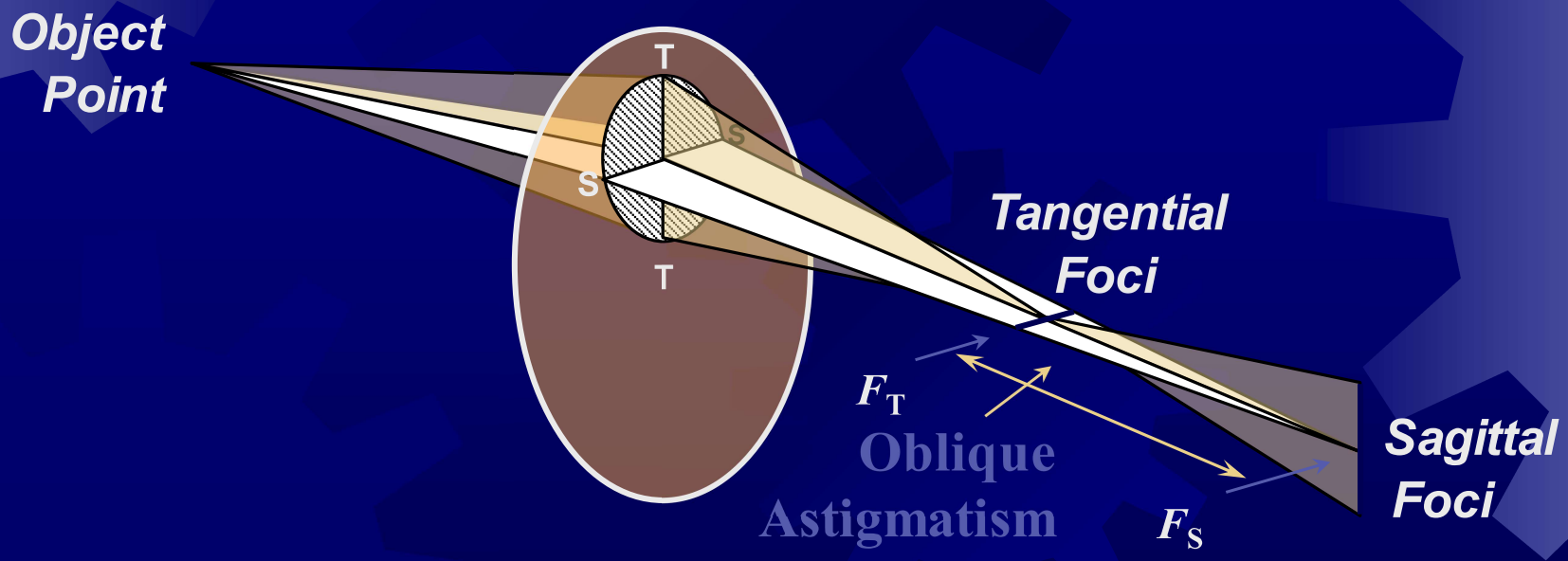
undistorted

pincushion distortion

barrel distortion

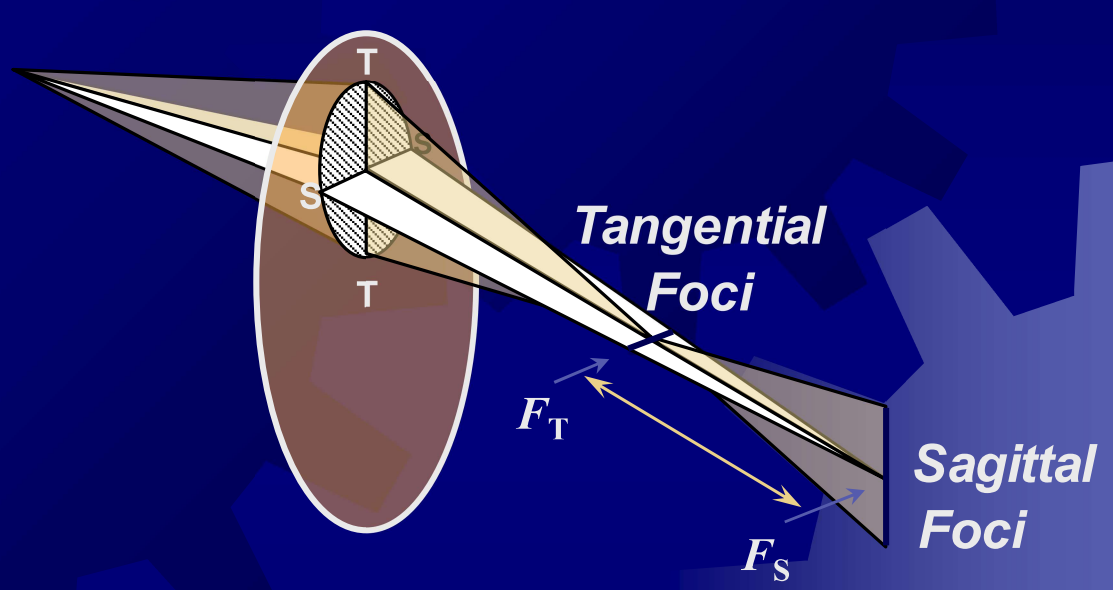
Off-axis Errors

- ***Oblique astigmatic error*** and ***power error*** are lens aberrations that blur vision in the periphery of spectacle lenses



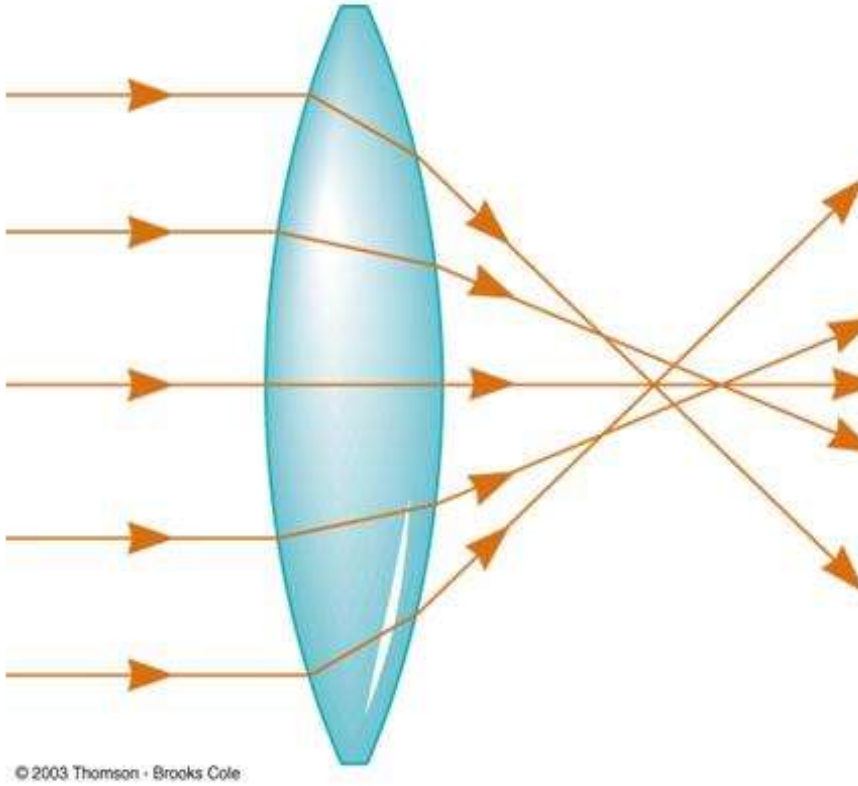
Oblique Astigmatism

- Also called marginal astigmatism
- Light passing through the lens focuses away from the horizontal or vertical meridians
- Lens designers can usually control the problem



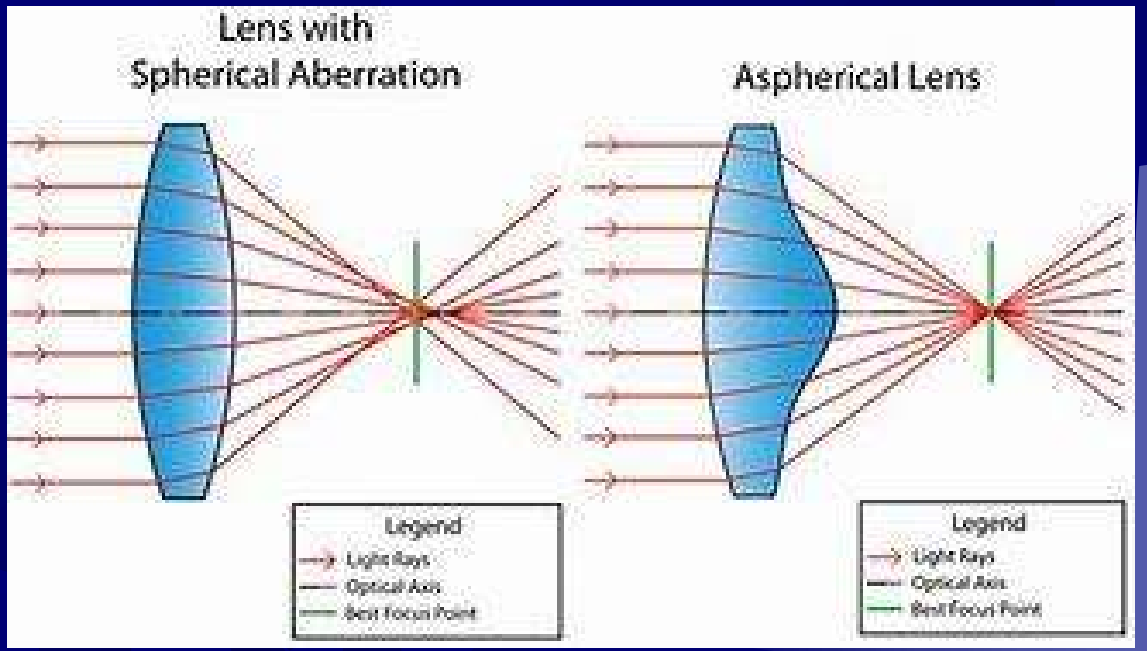
Spherical Aberration

- For a lens, spherical aberration results from the focal points of light rays far from the principle axis are different from the focal points of rays passing near the axis



Spherical Aberration

- The image viewed through a lens with spherical aberration has a noticeable “softness” to it.



- Use aspherics and atorics

Coma Aberration

- A defect in the imaging of objects off the optical axis in which there is a bright central area and a tail of lesser brightness

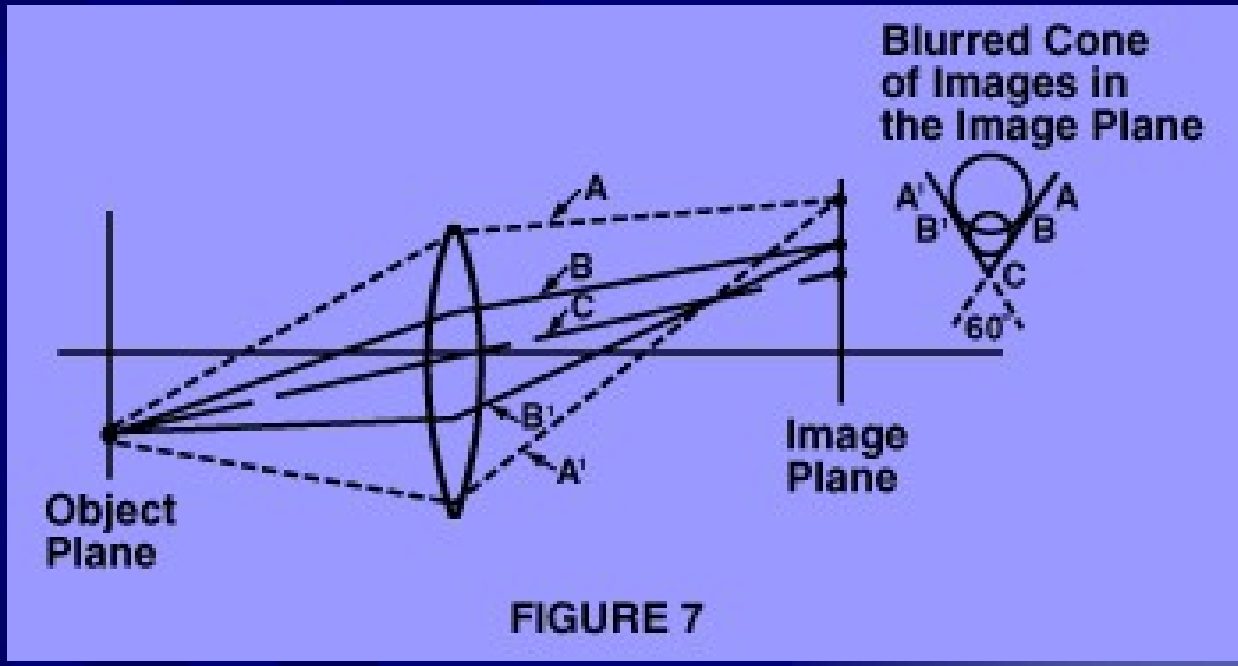
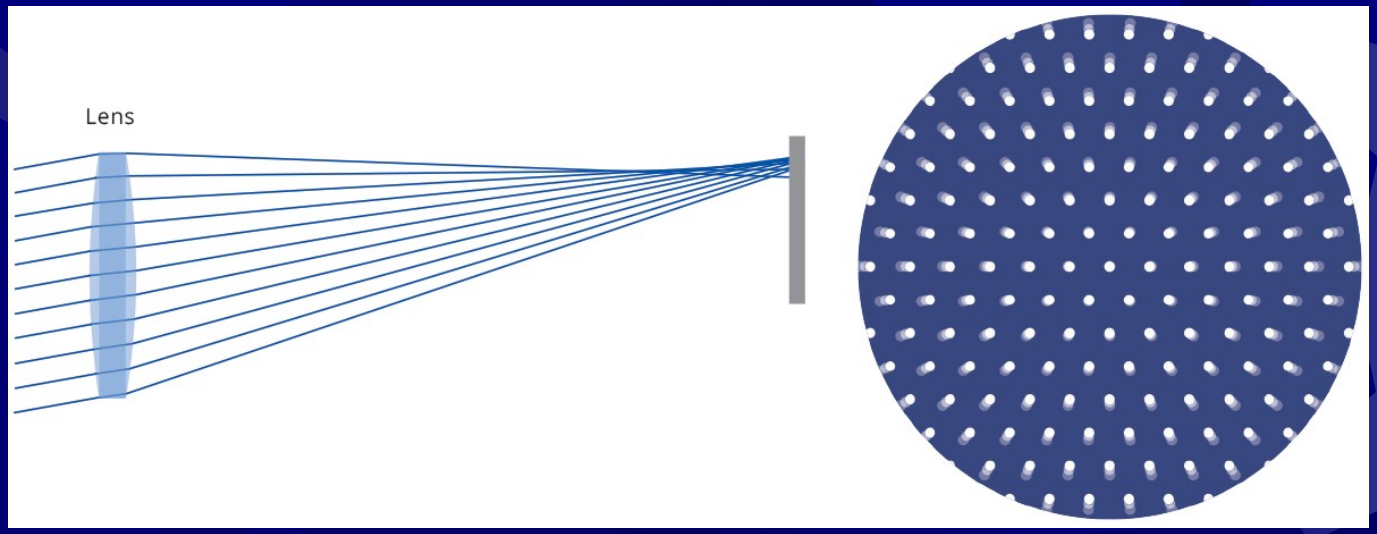


FIGURE 7

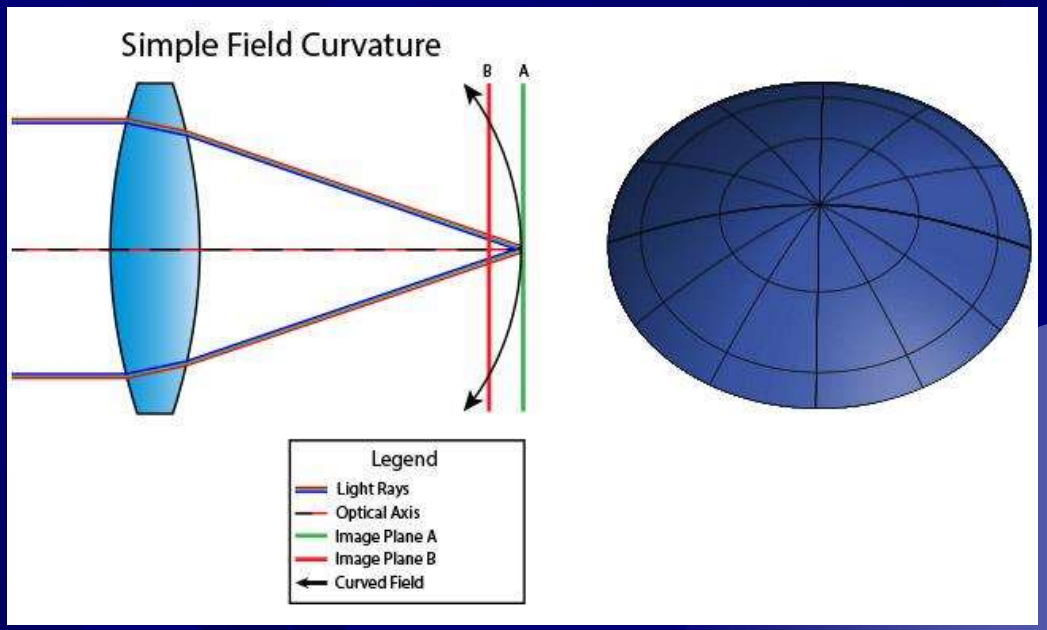
Coma

- A lens designed without correction for coma will cause the viewed images to have a comet-like extension.



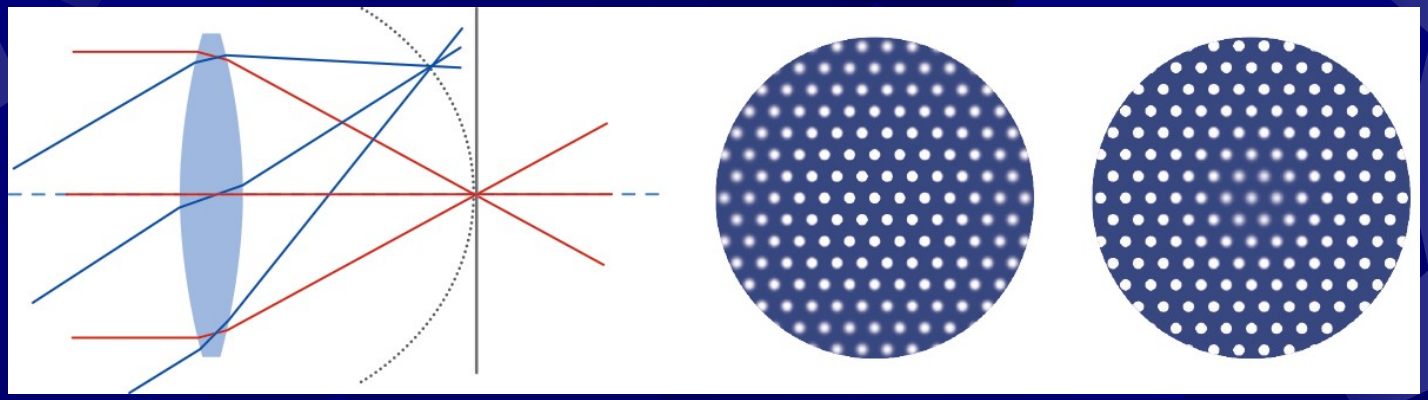
Curvature of Field

- The center of the image is in focus, while the periphery is out of focus



Curvature of Field

- An image defect that causes off-axis image points to focus in different planes
- Can be minimized in lens design



Problems Associated With Strong Power Lenses

- Increased magnification or minification, both from the patient's and viewers perspective
- Increased weight
- Increased thickness (cosmetic appearance)
- Potential for problems with prism
- Potential for problems with vertex distance

Anisometropia

- Anisometropia is used to describe the clinical situation that exists when the dioptric values of a patient's right and left spectacle corrections are unequal
- The term antimetropia is sometimes used if one eye is myopic and the other hypermetropic
- This may be meridanal magnification in one lens resulting in aniseikonia

Aniseikonia

- Unequal retinal image sizes for the two eyes
- Usually the result of unequal refractive errors that may be congenital, a result of LASIK curvature drift or post-cataract Rx. error or mispositioning of IOL
- May be resolved with iseikonic lenses

Visual discomfort due to:

- Unequal retinal image sizes
- Unequal prism differences at near point
- Unequal focus

Factors That Influence Magnification in Spectacle Lenses

- Power
- Thickness
- Radius of Curvature

Magnification

- Generally an inconsequential side-effect of corrective lenses
- Problematic when the wearer undergoes changes in correction or when significantly different in each eye
- Plus lenses produce magnification
- Minus lenses produce minification

Magnification

- Magnification can be viewed as a positive or negative.
- Equalizing magnification is the key

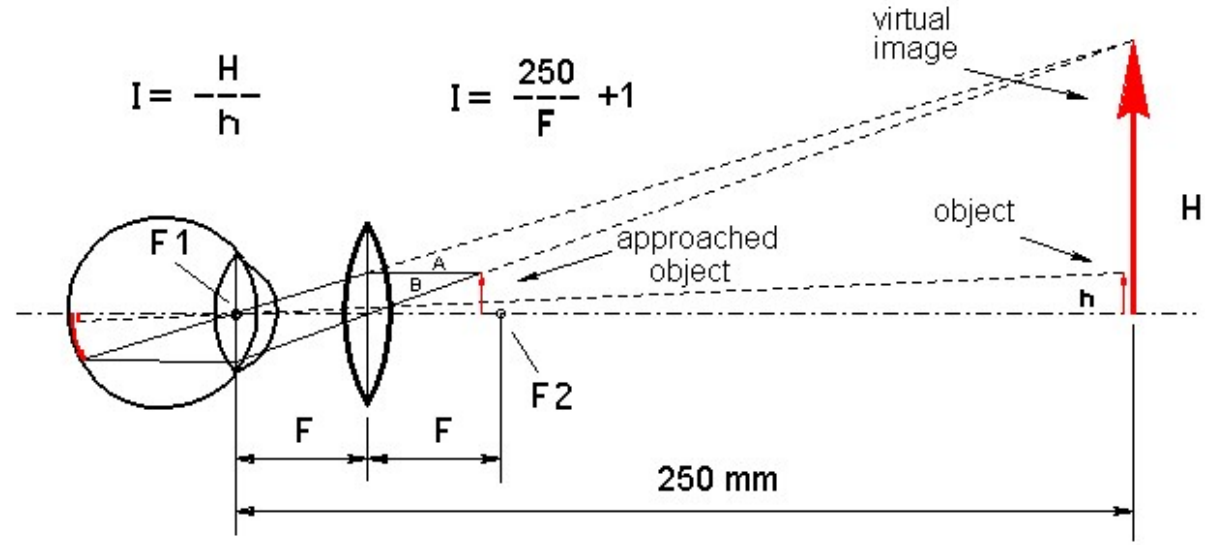


Fig. 4 . The magnifying lens allows objects to be brought closer to the eye while still seeing them clearly. This produces an increase in their apparent size.
F = focal length
250 mm = conventional distance of the near vision

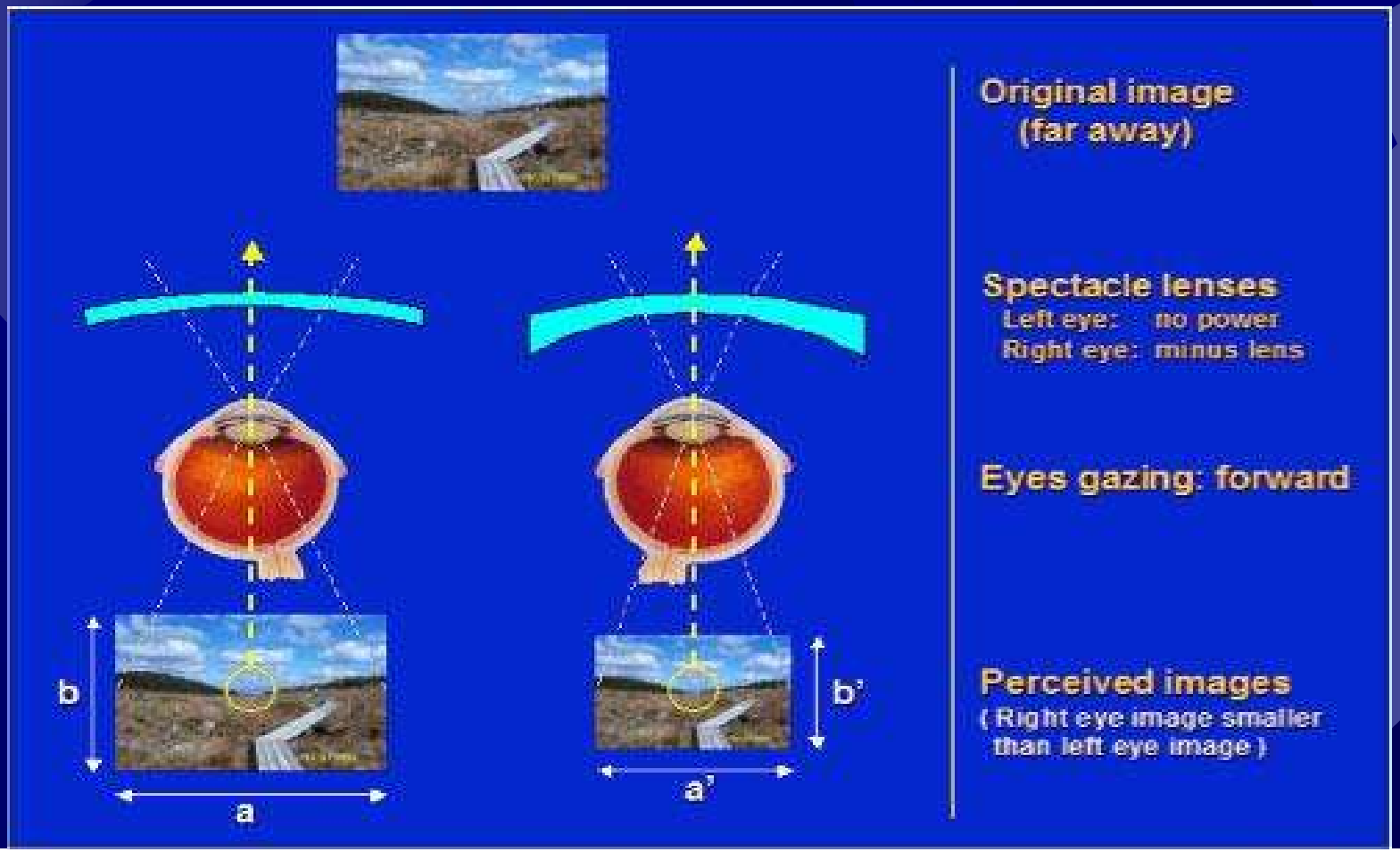
Magnification Due to Shape

- Modifying front curve
- Increasing center thickness
- Changing the vertex distances increases magnification in plus lenses and increases minification in minus

Steepen Base Curve	• Increase magnification • Decrease minification
Flatten Base Curve	• Decrease magnification • Increase minification
Increase in thickness	• Increase magnification • Decrease minification
Decrease in thickness	• Decrease magnification • Increase minification
Increase in vertex distance	• Plus lens increases magnification • Minus lens increases minification
Decrease in vertex distance	• Plus lens decreases magnification • Minus lens decreases minification

Magnification Due to Power

- The greater the power, the greater the magnification or minification effect



Handling Magnification

- There is not much that you can do, because you can't change the power, which plays the largest role in magnification
- You can reduce magnification by flattening front curve, but this may cause other optical problems (use high index)
- You can also reduce magnification by reducing thickness (high index and aspherics)

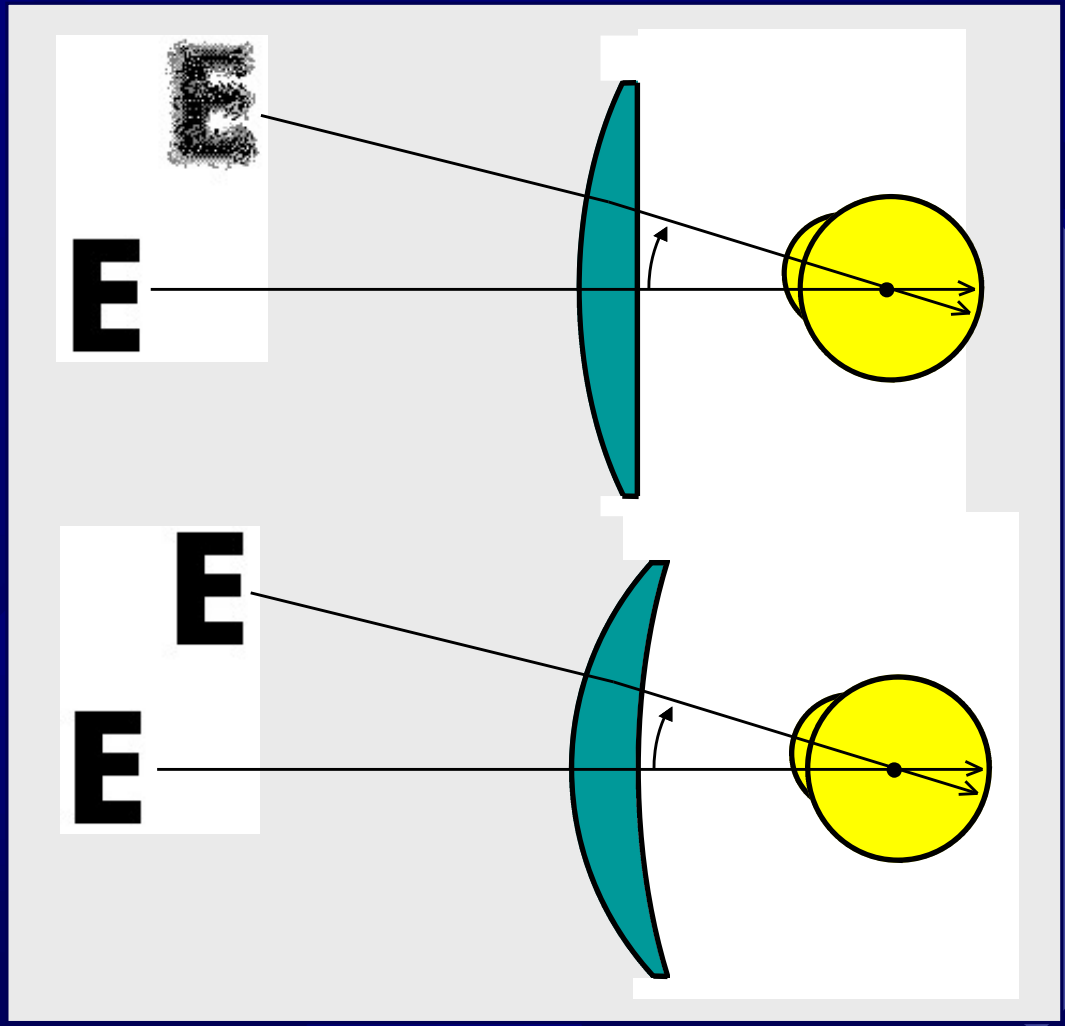
Using a Flatter Front Curve

- While the selection of a flatter curve has cosmetic advantages, it may have serious optical disadvantages
- In anisometropia, compromises must be made
- We might choose to sacrifice usable lens area to equalize image magnification, and achieve binocularity

Peripheral Vision Comparison

Vision through a *flattened* lens.

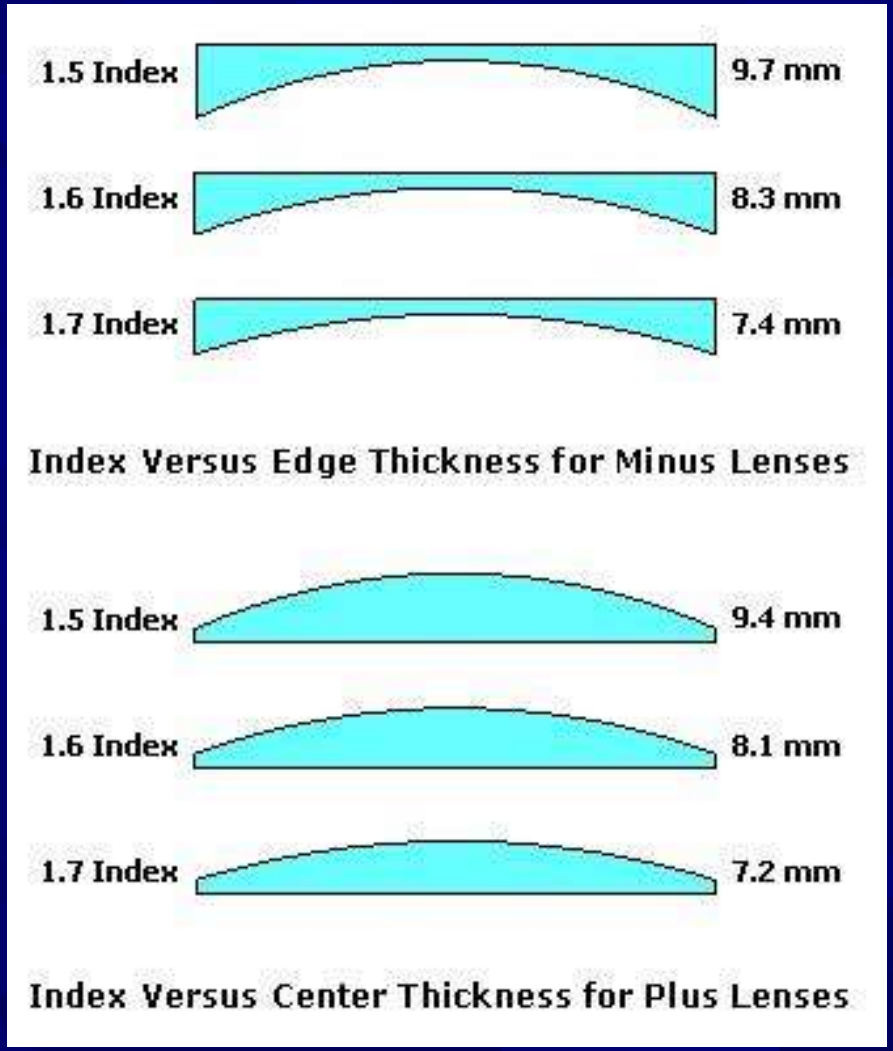
Vision through a *best form* lens.



Handling Lens Thickness

- Use High Index with the Flatter Front Curve it will likely utilize
- Use Aspherics
- Use Small Frame ED
- Minimize decentration

Controlling Thickness - Index



Avoiding Problems With Prism in Strong Lenses

- It is essential to center lenses in both the horizontal and vertical planes
- This is particularly true when you have strong Rx., aspheric lenses, high index, or an anisometropic Rx.

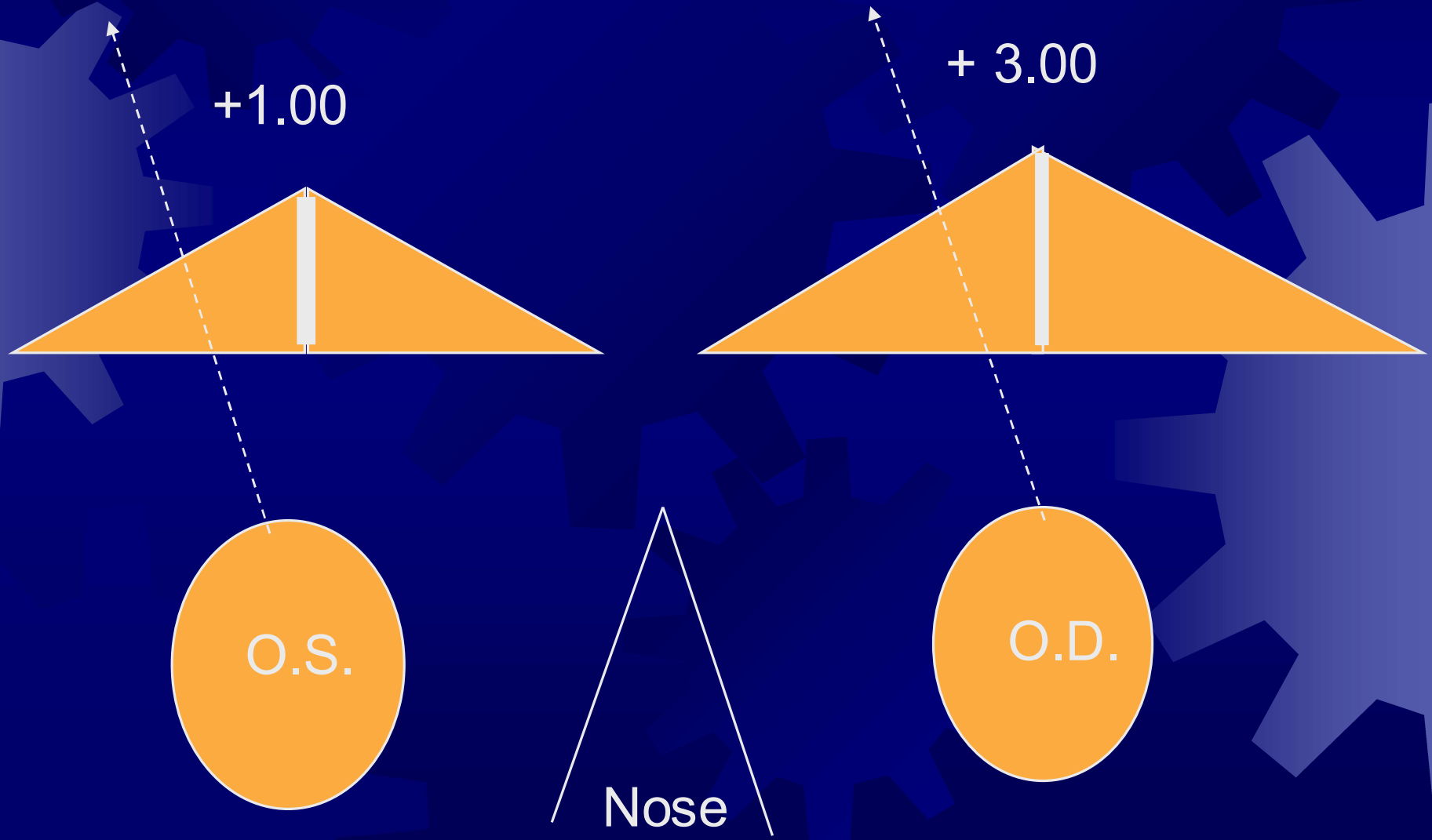
Horizontal Imbalance Problems

- Using the Rx O.D. +3.00
  O.S. +1.00

Looking left will cause base out prism OD

Looking right will cause base in prism OD

SINGLE VISION DISPLACEMENT



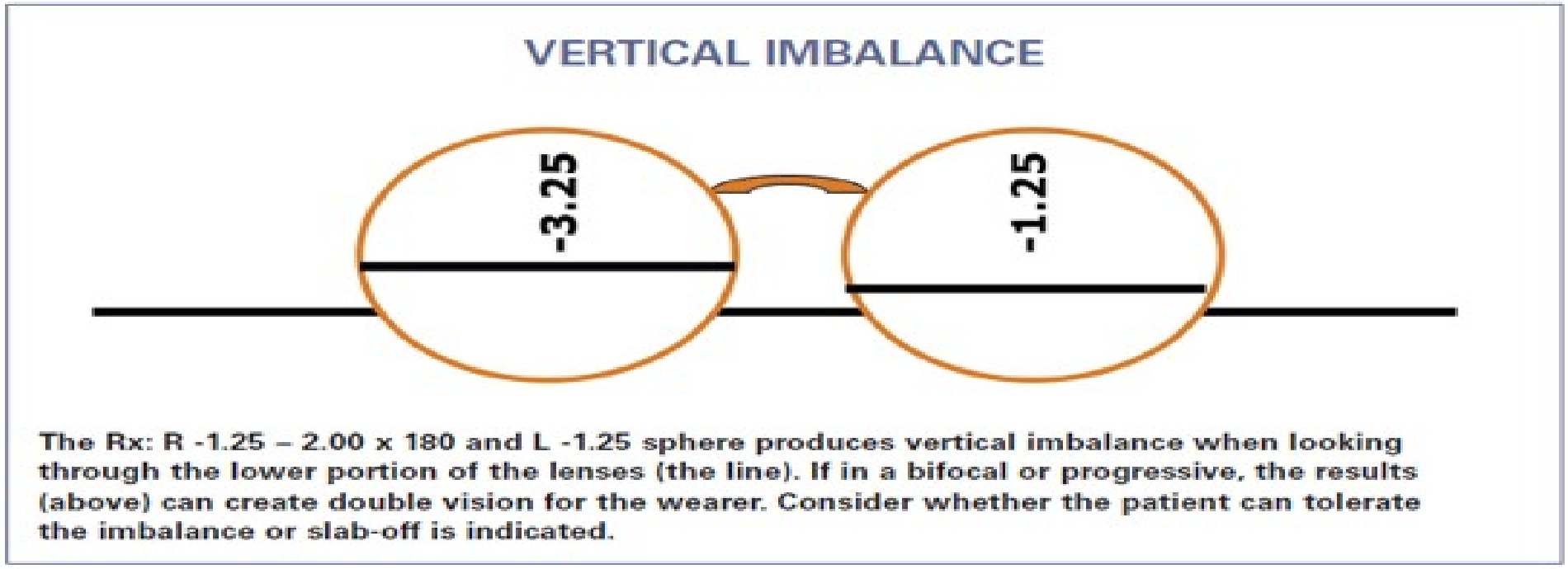
Correction for Horizontal Imbalance:

- Eye is capable of horizontal fusion of large amounts of prism.
- Patient self corrects this problem by turning their head in direction of gaze (become “head-movers)

Vertical Prism Problems

- In the vertical plane, anisometropia causes vertical prism imbalance.
- Rx's with varying amount of power in the 90th meridian create opposing or unequal amounts of prism at the reading level (the point the patient is looking through).
- Average person tolerates vertical imbalance of up to 1.5 prism diopters.

What is Vertical Imbalance ?



- Simply put, vertical imbalance is a loss of visual clarity resulting from a prism effect in the 90th meridian.

Who is Bothered by Vertical Imbalance ?

- First time multifocal wearers that have a decided difference in Rx's of each eye.
- Multifocal wearers with good acuity but whose Rx has changed sufficiently to induce 1.5 prism diopters of vertical imbalance or more.
- A pseudophakic patient, or a regressed LASIK patient with anisometropia.

Who is Not Bothered by Vertical Imbalance ?

- Single vision wearers may not be bothered. They experience 0 prism through the optical center of their glasses, and adjust their head position.

- In the case of unequal Rx's, but only good acuity in one eye. Patient is only getting acceptable acuity in one eye only. No imbalance induced, eyes are not being used binocularly.

Handling Weight

- Use High Index
- Use Aspherics
- Use small frame ED
- Minimize decentration

Professor Jim Coleman

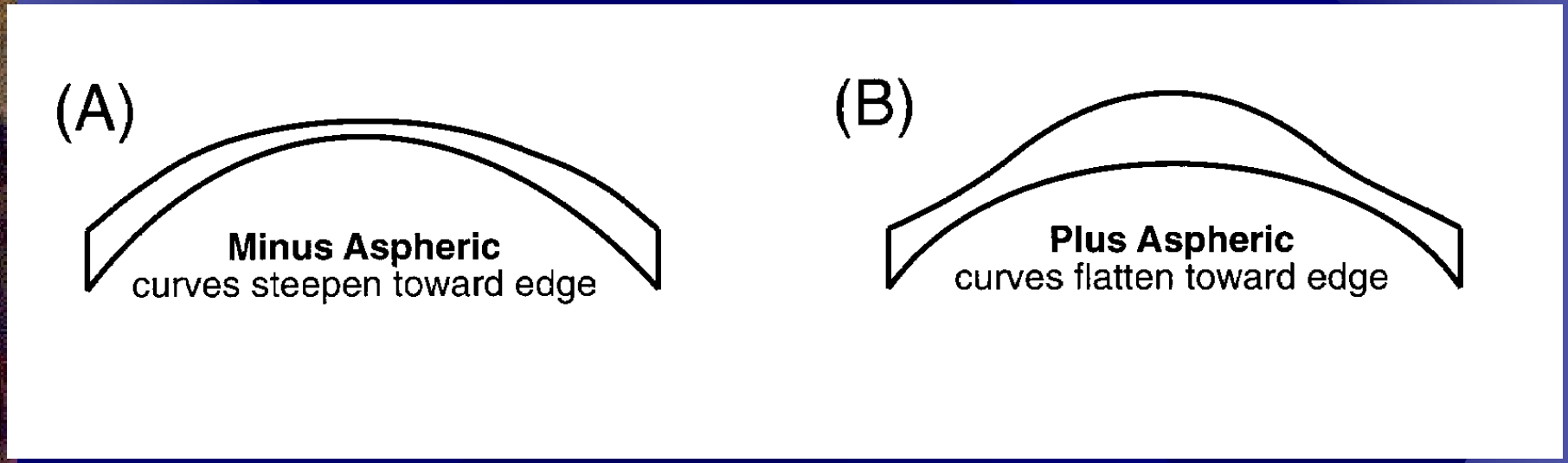
- I had a teacher nearly 50 years ago that said “In the future all lenses will be aspheric”.
- He also predicted that “if the lens designers were smart they would find a way to aspherize the back surface”
- We are not quite there, but close. He was a pretty smart guy

Aspheric Lenses

- A surface that departs slightly from a fixed radius of curvature
- Used to reduce lens weight and thickness
- Utilize flatter base curve in plus lense
- Reduce distortion

Aspheric Lens Design

- A variance of anterior or posterior radius of curvature



Atoric Lenses

- Atoricity is an extension of aspheric design technology, allowing lens designers to optimize for *both* the sphere and cylinder powers of a lens.
- This ensures that nearly all wearers enjoy the same wide field of vision, especially those with astigmatism.

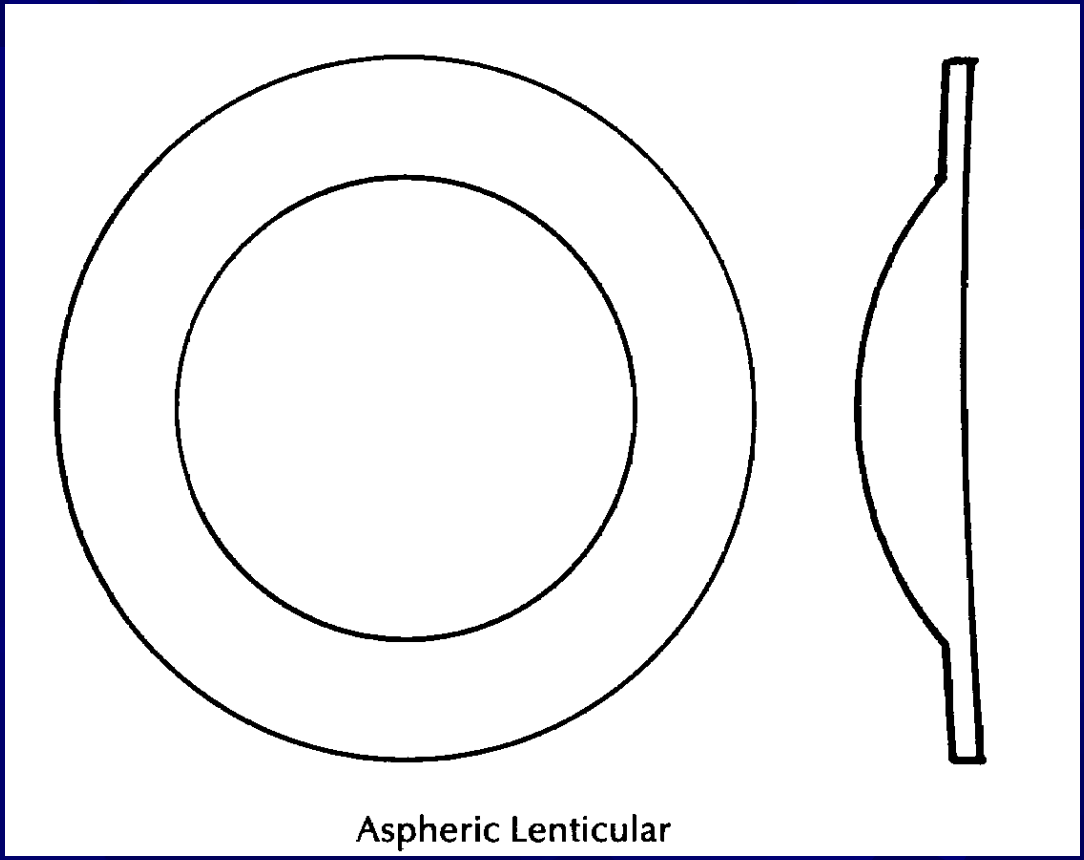
Atoric Lenses

- Atoric lenses consistently outperform either best form (with spherical base curves) or rotationally symmetrical aspheric lenses across a wide range of prescriptions.

Special Lens Products for Strong Powers

- Aspheric Lenticular designs (aphakia or very high plus)
- Hyper-aspheric
- Myodisc (high minus)
- Minus Lenticular (high minus)

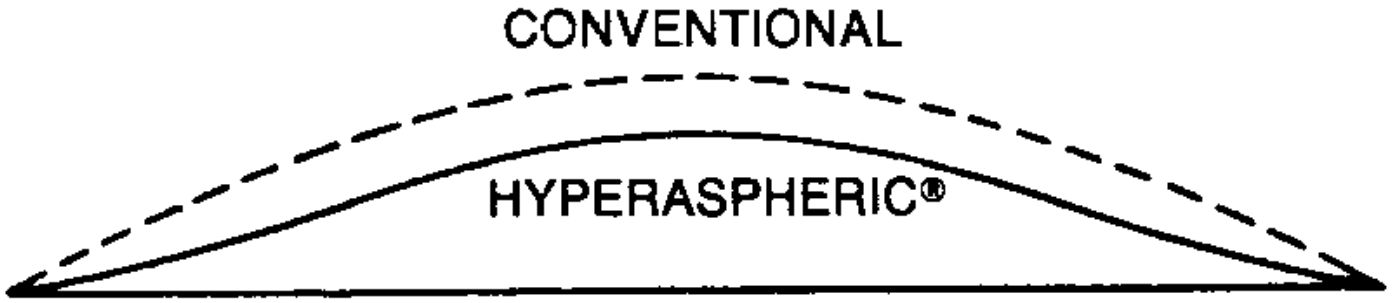
Plastic Aspheric Lenticular (The Original PAL)



Aspheric Lenticular

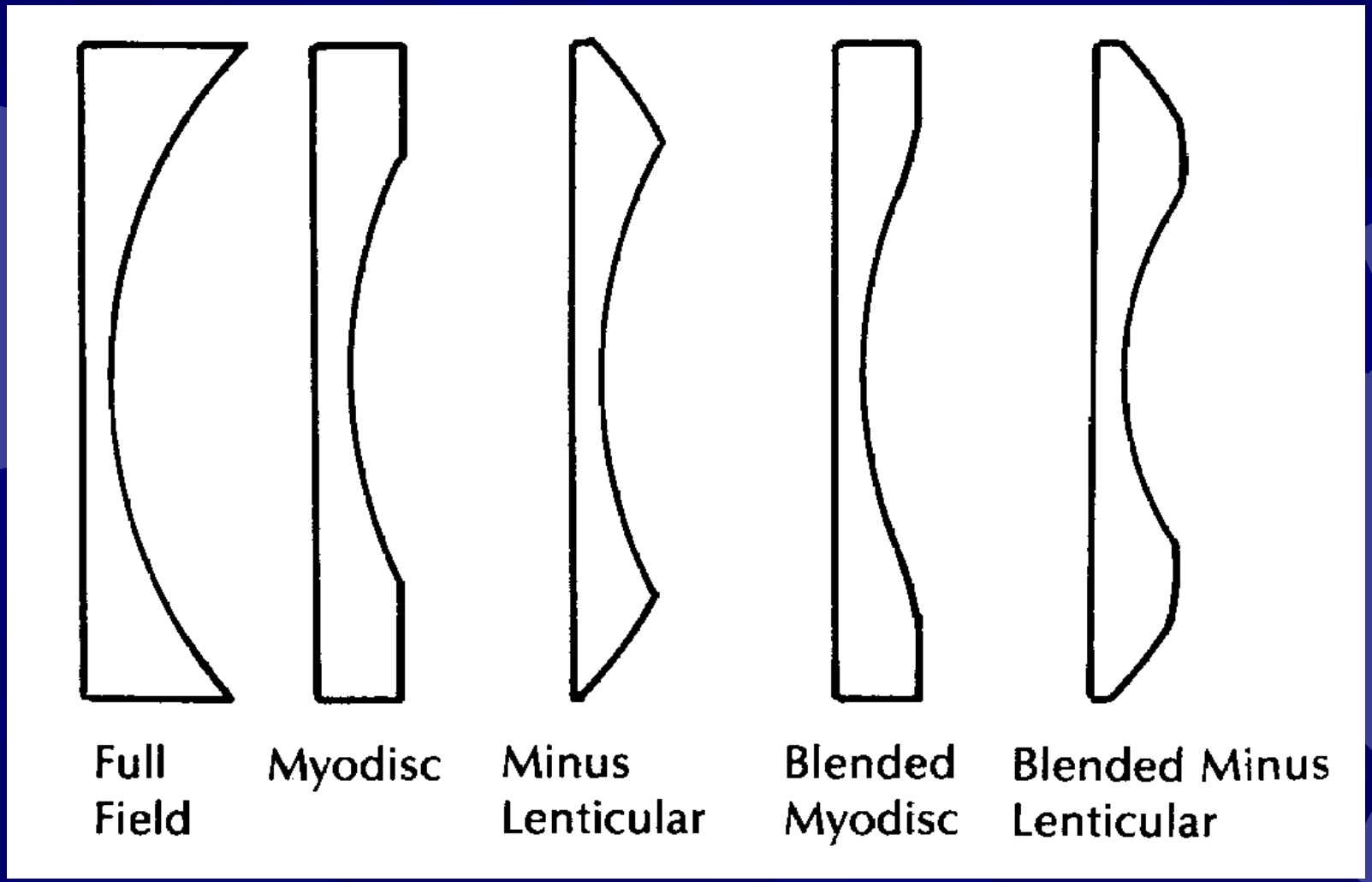
Aspheric Design - High Plus

- Improvement of field of view with Full Field Aspheric



Conventional Lens vs. Full Field Aspheric
Fig 3-8

Lenses for High Minus

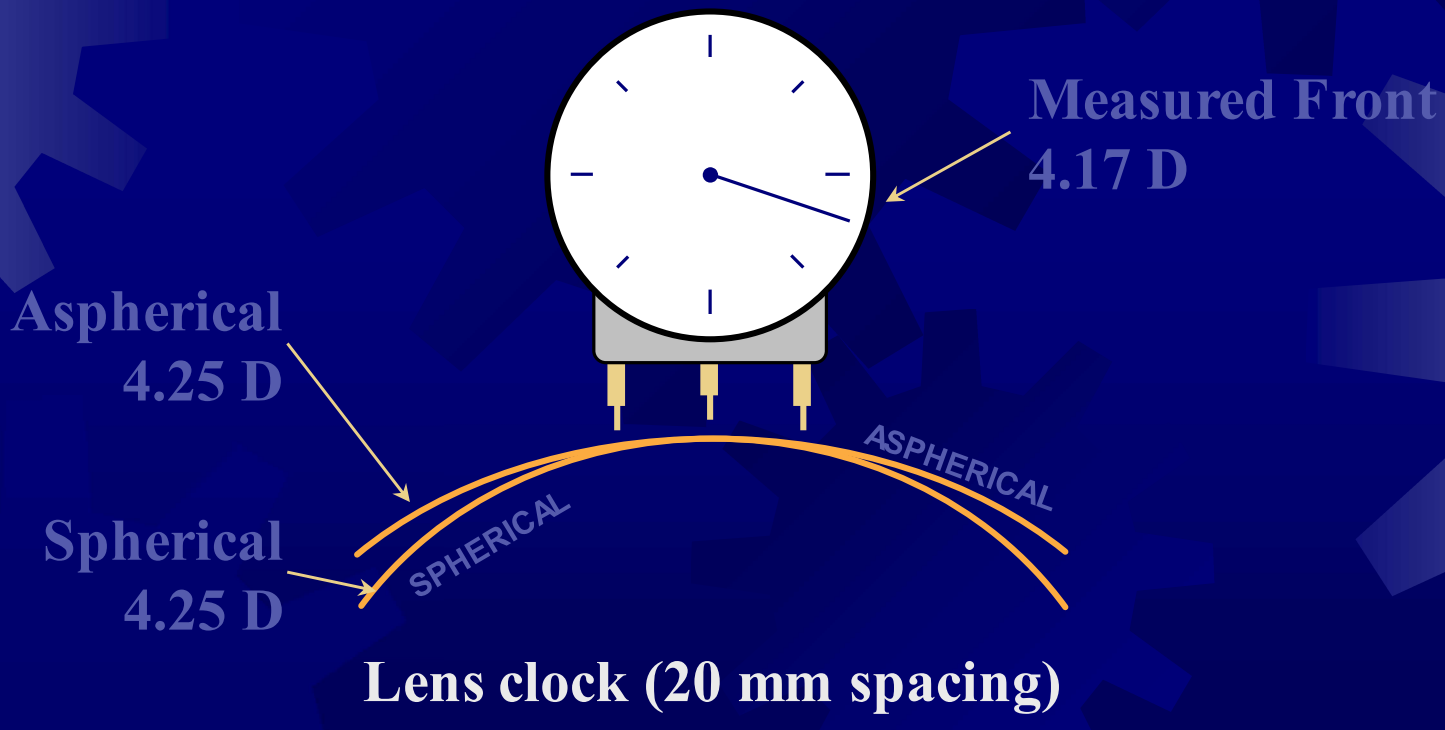


Lens Tilt and Astigmatism

- When the optical axis of the lens does not pass through the center of rotation of the eye, spherical and astigmatic errors are induced
- Errors increase sphere power and introduce a cylindrical effect (same sign) at 180°
- Effects are more significant with aspherics and high-powered lenses

Lens Clocks and Aspherics

- A lens clock may show a slight error when measuring aspheric surfaces



Resources – Thanks to:

- The Nikon Corporation
- JML Optical
- The National Academy of Opticianry
- Jobson – 20/20 Magazine