Lens form and analysis

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On behalf of Vision Expo, we sincerely thank you for being with us this year.

Vision Expo Has Gone Green!

We have eliminated all paper session evaluation forms. Please be sure to complete your electronic session evaluations online when you login to request your CE Letter for each course you attended! Your feedback is important to us as our Education Planning Committee considers content and speakers for future meetings to provide you with the best education possible.

VISION EXPO

Financial Disclosure

Carrie Wilson has no financial interests to disclose.

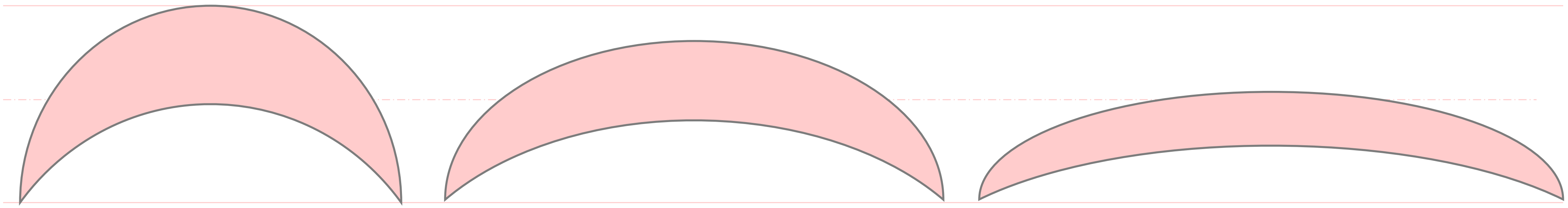
By the end of this class, you should have a greater understanding of:

- The shape and design of ophthalmic lenses
- Vertex Distance
- The importance of base curves
- Aberrations
- Determining the power of a compound lens in any given meridian.

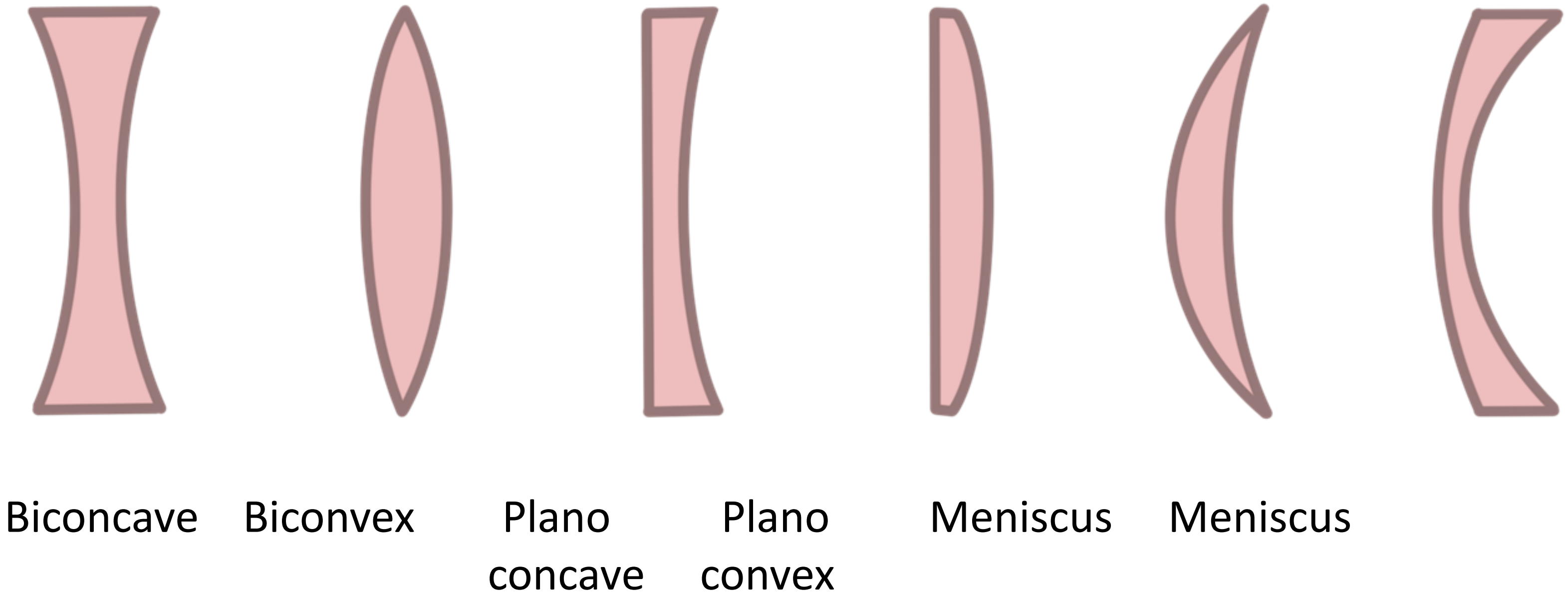
LENS FORM & DESIGN

Radius of Curvature

Larger Circle or Sphere	Smaller Circle or Sphere
Longer radius of curvature	**S**horter radius of curvature
Flatter Curve	**S**teeper Curve
Weaker Power	**S**tronger Power



PLUS AND MINUS LENSES



Plus and Minus Lenses

Plus Design

- More convex
- Base curve steeper than ocular curve
- Plus curve is always stronger than the minus curve
- Meniscus design is used for most current ophthalmic plus lenses

Minus Design

- More concave
- Base curve is flatter than the ocular curve
- Minus curve is always stronger than the plus curve
- Meniscus design used for 98-99% of all ophthalmic Minus lenses

Plus and Minus Lenses

PLUS LENSES	MINUS LENSES
Magnify	Minify
Against Motion	With Motion
Thicker in Center	Thinner in Center
Two Prisms Base to Base	Two Prisms Apex to Apex
Real Focus Point	Virtual Focus Point
Corrects Hyperopes	Corrects Myopes

Cylindrical Lenses

- Has spherical front surface and a toric back surface (two separate curves placed 90 degrees apart)
- Exhibits characteristics of either the plus or minus spherical lenses dependent on the total power of each back surface.
- Has diagonal cutting motion (scissoring)
- Edge thickness is uneven
- Magnifies differently in the two principal meridians

ABERRATIONS

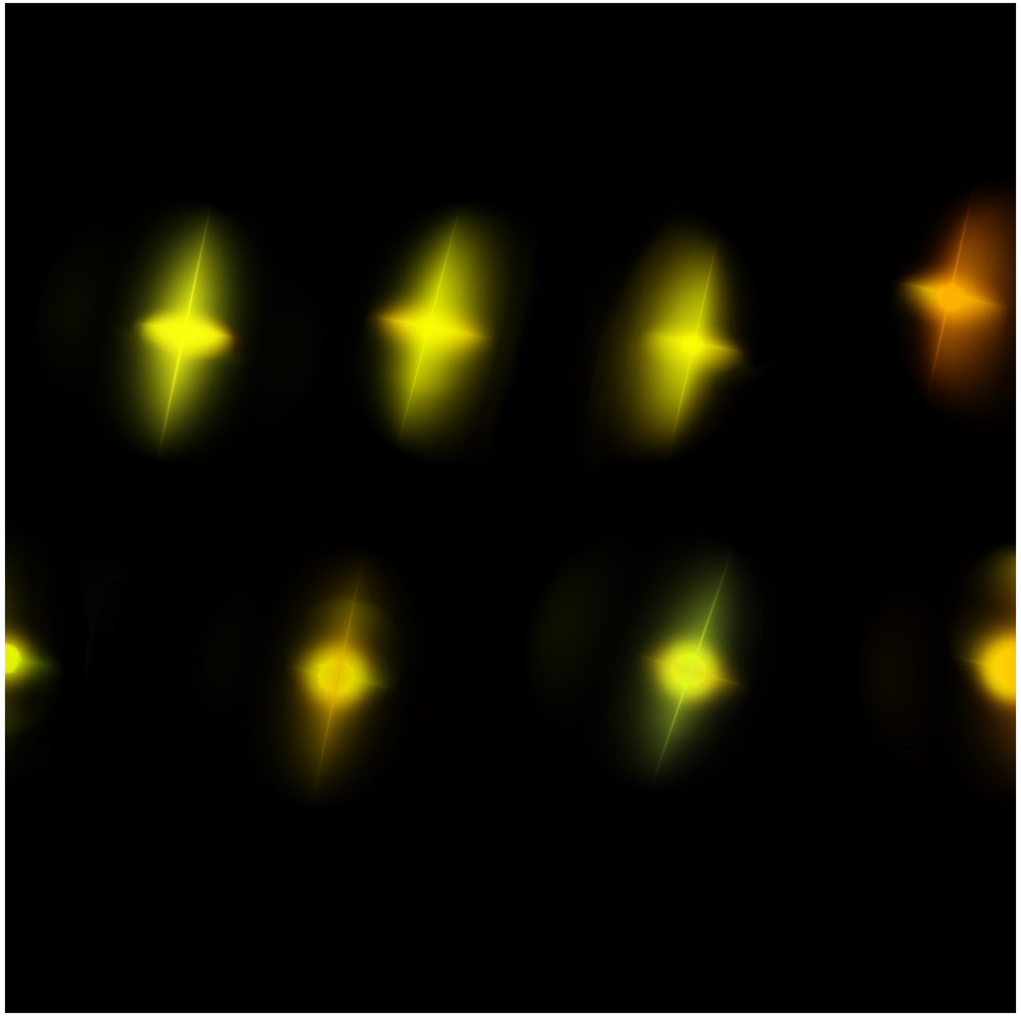
Chromatic Aberration

ABBE Value

ABBE value is a correlation of how much a lens may refract light without breaking it down into component colors.

Lower ABBE values are more susceptible to chromatic aberration because they scatter light more.

Material	Refractive Index	ABBE
Crown Glass	1.52	58
CR-39	1.49	58
Trivex	1.53	43-45
Hi-index	1.60+	36
Polycarbonate	1.586	30

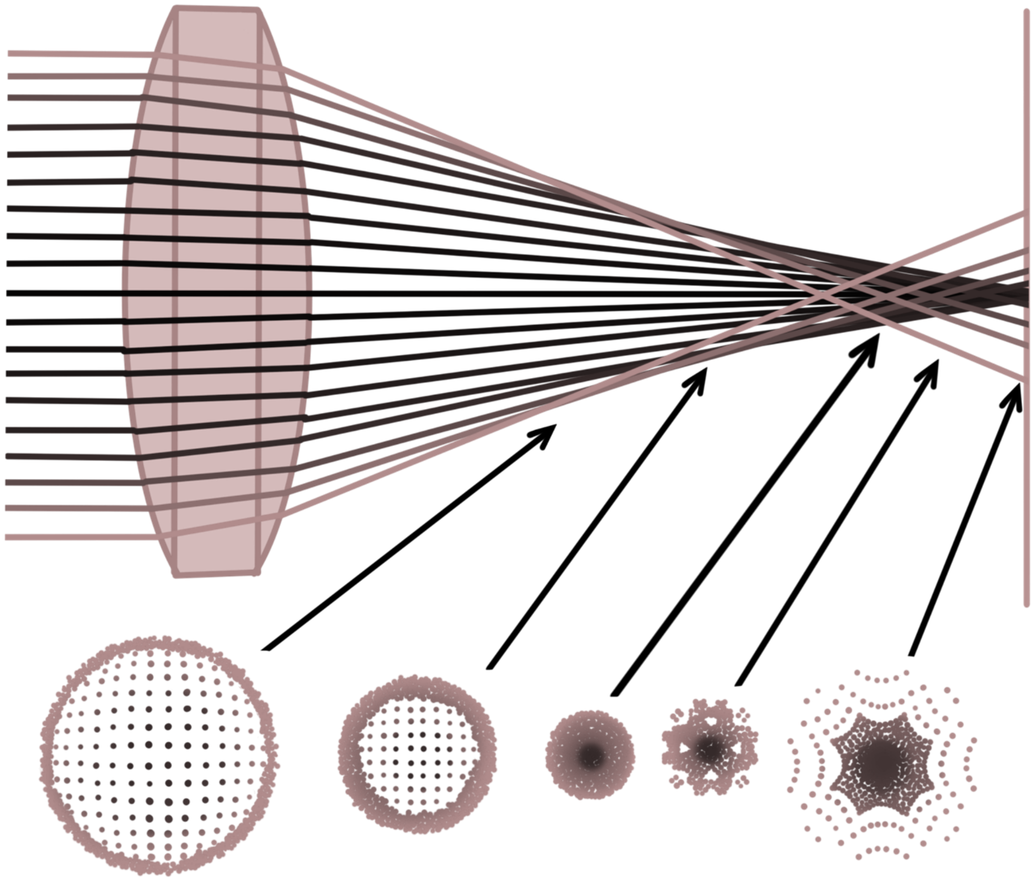


Coma

Typically, this isn’t an issue, as the pupil acts as an aperture by restricting the lens region that admits rays of light into the eye.

Coma can be partially ameliorated (improved/reduced) by carefully choosing the base curve and lens material and keeping the lens size small, i.e., recommending smaller frames.

Spherical Aberration



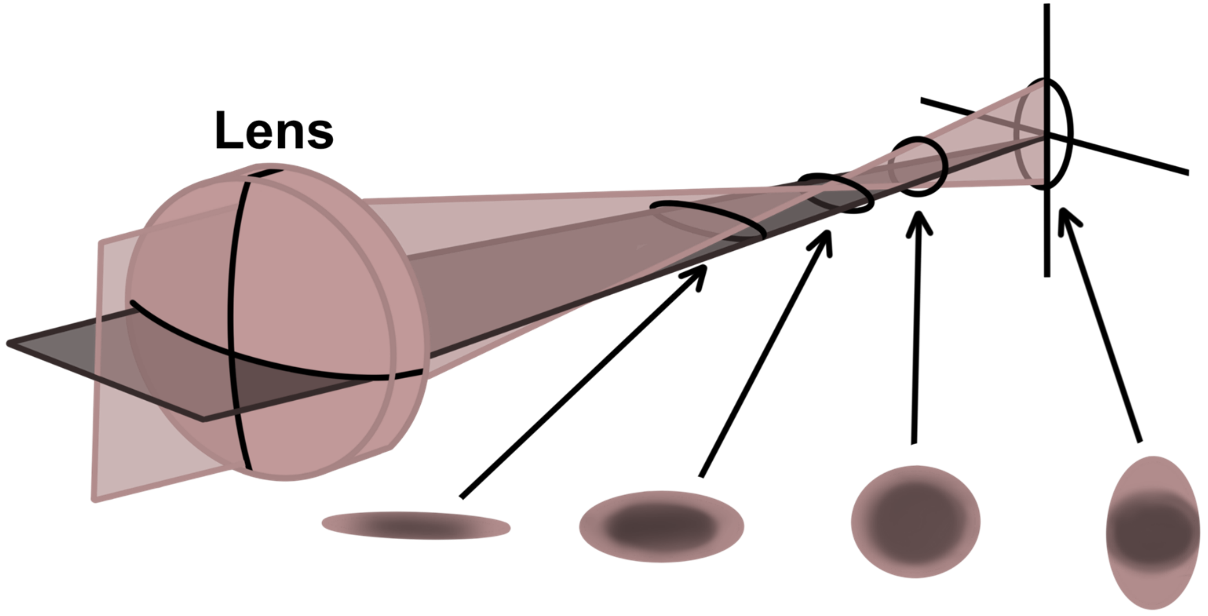
Spot diagram

It tends to affect spherical or freeform lens design and can be corrected with aspherical lenses.

Caused because the rays entering the lens from the side have a shorter focal length than those entering closer to the center.

Results in blurry vision in the periphery of the lens.

Corrected by adjusting pantoscopic tilt, vertex distance, frame size, and/or base curve



Marginal Astigmatism

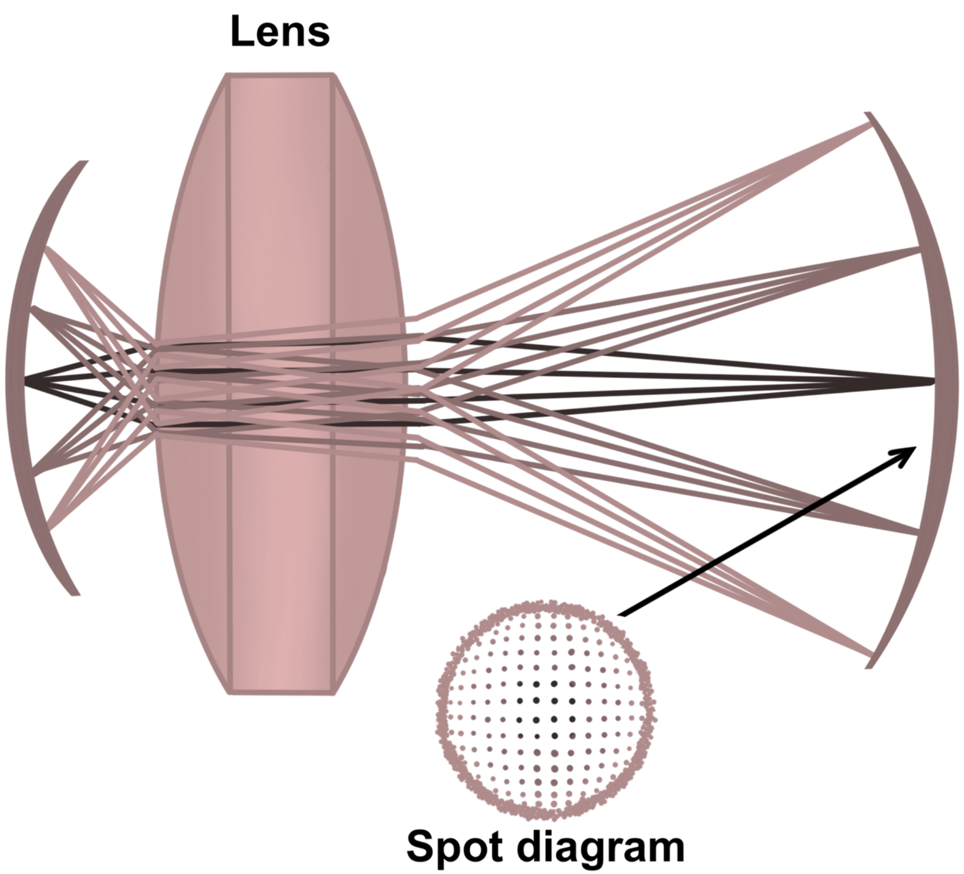
In lens design, it is also called oblique astigmatism or radial astigmatism.

An undesirable sphere and cylinder power gain when looking away from the optical center. It is caused by a beam entering obliquely to the lens's visual axis, affecting peripheral vision.

Creates excess power and cylinder.

Corrected by

- adjusting pantoscopic tilt/OC height,
- using aspheric lenses for Rx's with high powers and/or big frames.



Curvature of Field

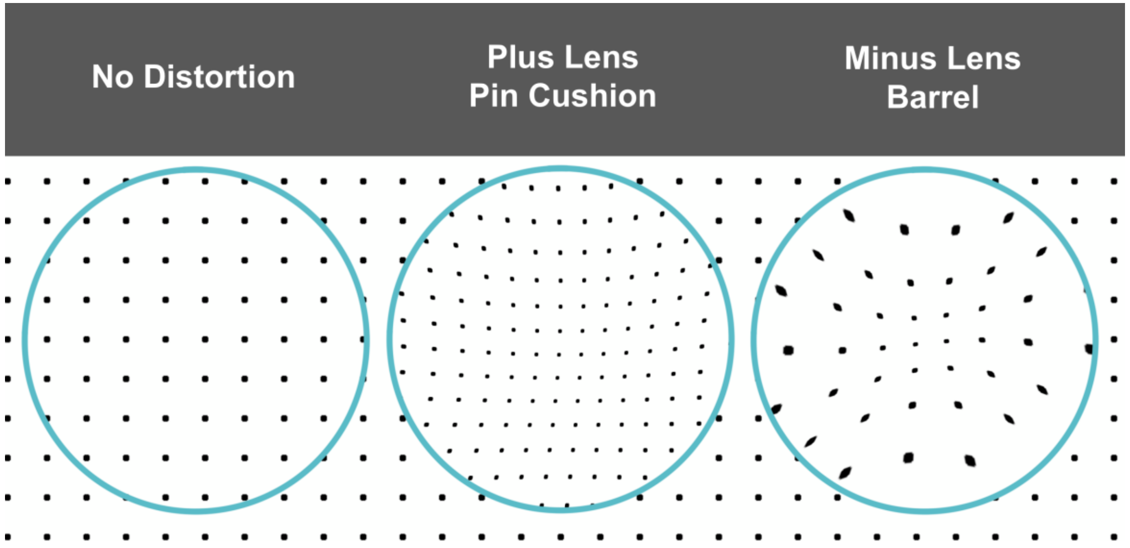
Also called Power Error.

Light does not focus on a flat focal plane, which is why the screens at drive-in movie theaters are curved: to focus the sides of the film as well as the center. The retina is also not a flat plane, so there can be a blur in the peripheral.

Caused by

- wrong base curve selection
- unequal vertex distance

Distortion



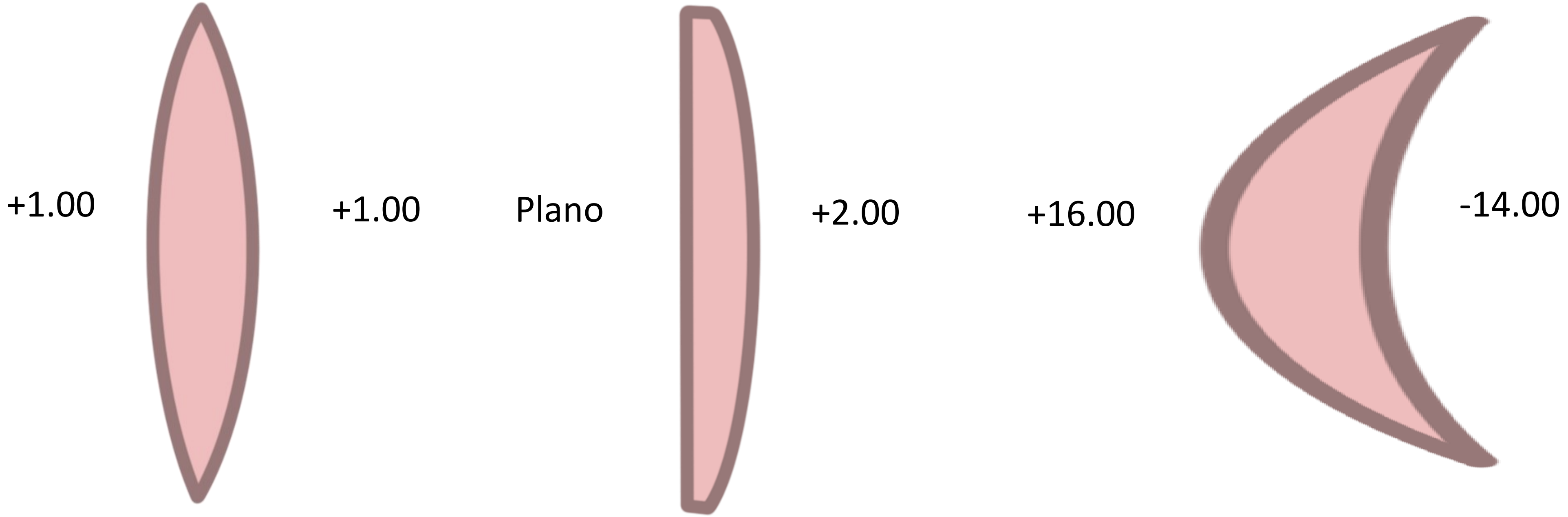
Distortion occurs as a result of unequal magnification across a high-powered lens.

Plus lenses produce more magnification on the corners of a square (instead of the sides) – pincushion distortion.

Minus lenses produce more minification on the corners of a square than the sides – barrel distortion.

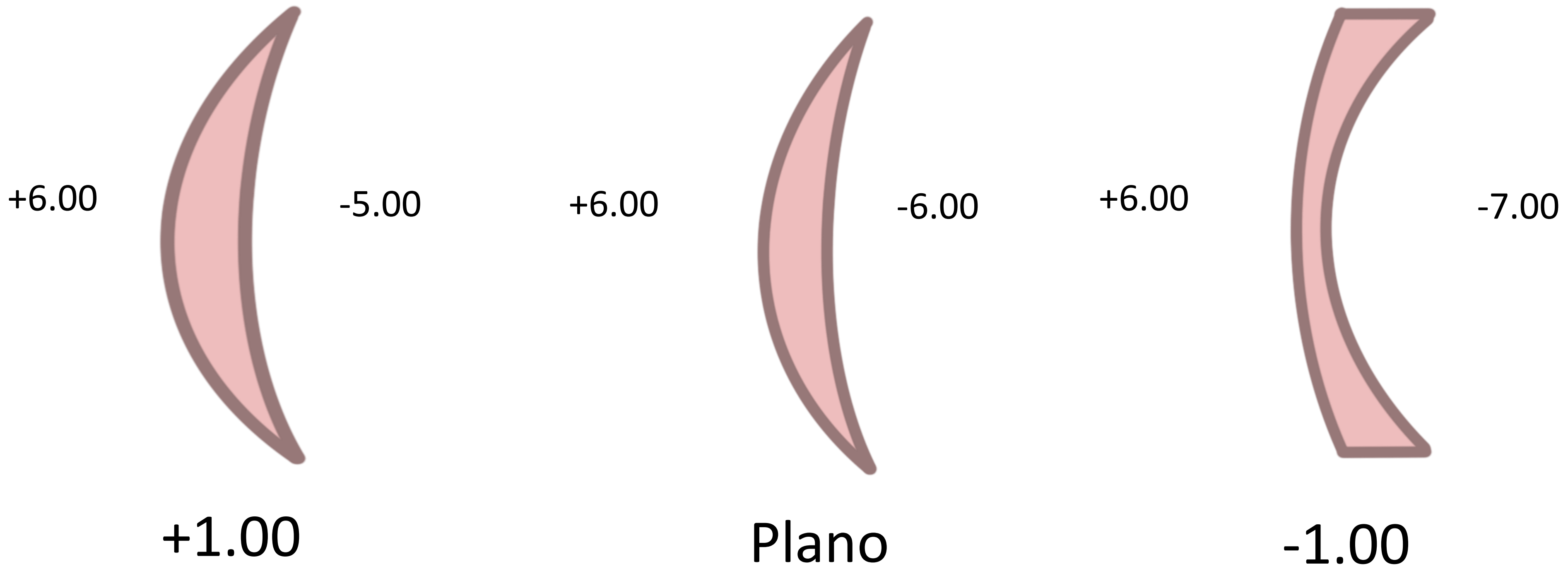
BASE CURVES

Spherical Shapes



All = +2.00 in power

Corrected Curve Lenses



BASE CURVE

COMMON BASE CURVE SELECTION CHART	
Power Range	**Base Curve**
+ 8.75 to +4.75	10.00 D
+ 2.25 to + 4.50	8.00 D
+ 2.00 to -2.00	6.00 D
-2.25 to -4.00	4.00 D
-4.25 to -7.00	2.50 D
-7.25 to -12.00	0.50 D

Visual Changes Caused by changes to base curve.

- A flatter curve will make objects appear smaller
- A steeper curve (more plus power in the base curve) will make images look larger.

High-index materials create lenses with naturally flatter base curves.

If more than one curvature power is discovered on a non-aspheric lens when checking curves at 180 and 90, it indicates a warped lens.

Nominal Lens Power

We can determine a lens's "nominal" power by adding the front surface power to the back surface.

What is the nominal power of a lens with a +7.00 front surface and a -3.00 back surface?

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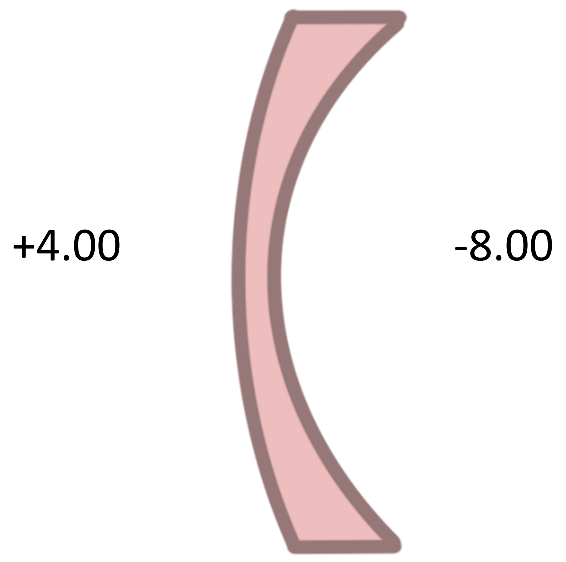
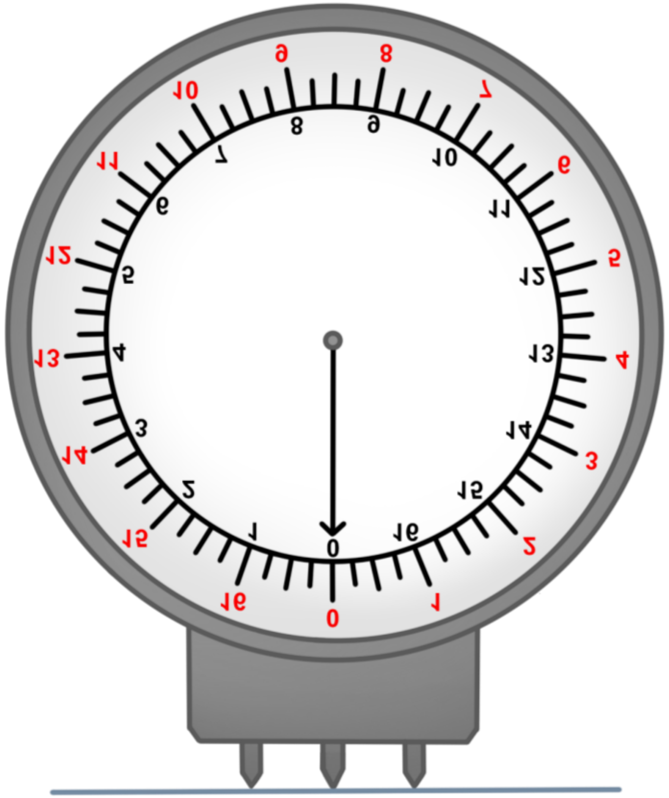
What is the nominal power of a lens with a +4.00 front surface and a -8.00 back surface?



Nominal Lens Power



Lens Clock

- Developed in Geneva, Switzerland so sometimes referred to as a Geneva Lens Measure
- Measures the curve of the lens to determine the power in diopters
- Calibrated to 1.53 index

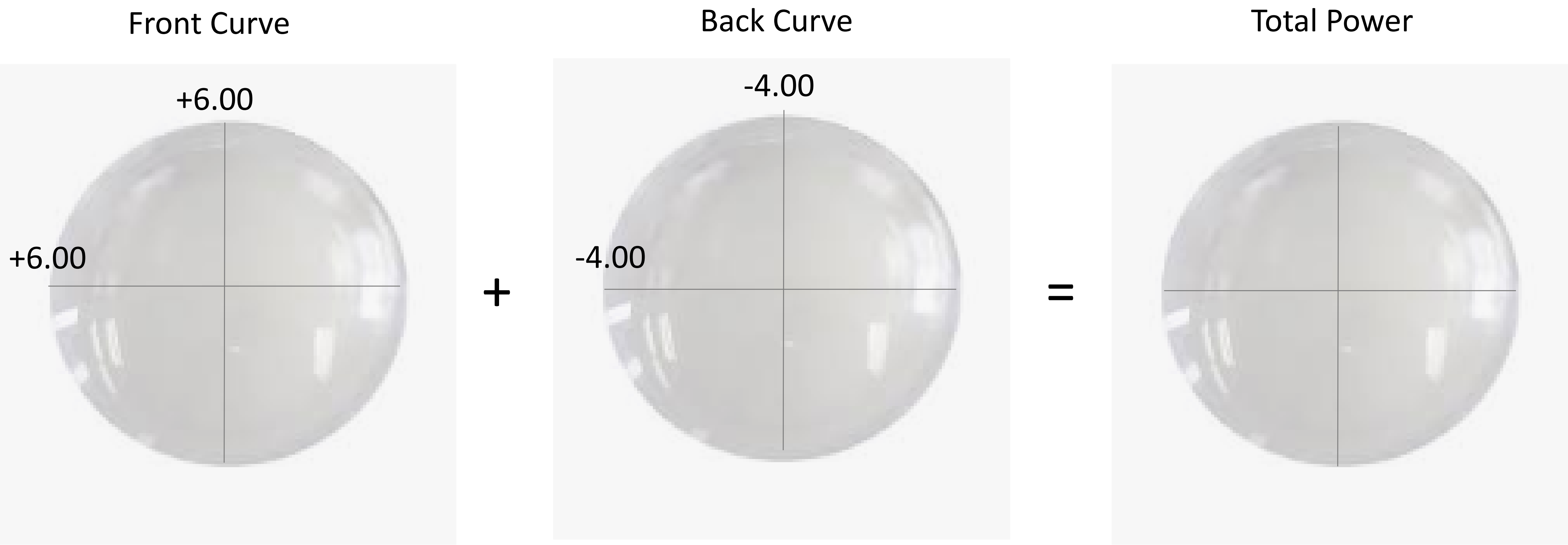
Using a Lens Clock

- Use a calibrated lens clock
  - Verify it reads zero by laying the legs gently on a flat surface at a perpendicular angle
- Do not tilt
  - Tilting the clock even 10 degrees can result in as much as 2 diopters of error when reading the lens.
- Determine the front surface curve of the lens (F1)
  - Here the front surface curve is +3.50.

Using a Lens Clock

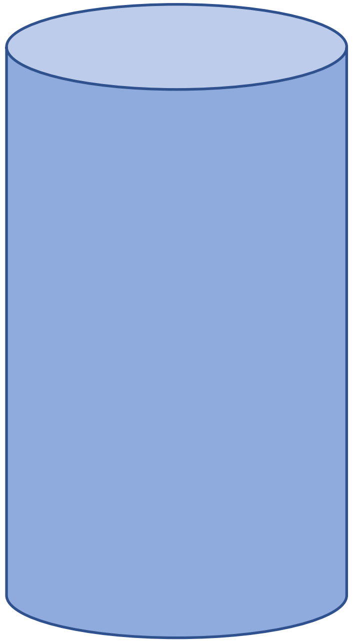
- Determine the back surface curve of the lens (F2)
  - Here the back surface curve is -7.75
- Add the front and the back surface curves together to determine the nominal power of the lens (FT).

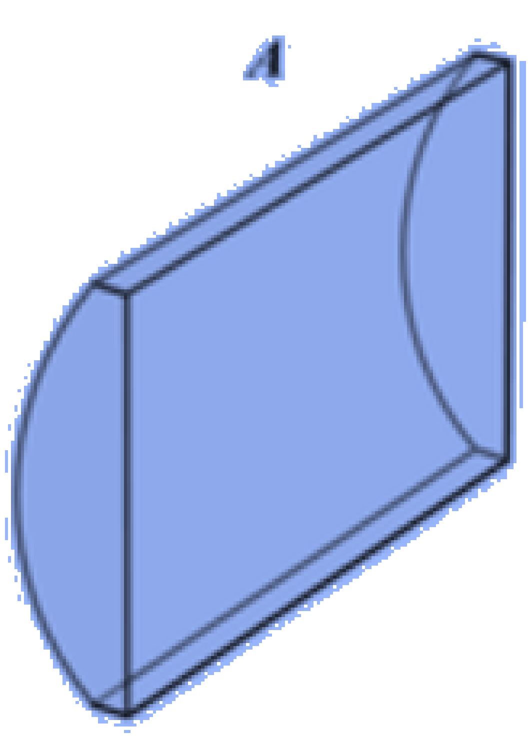
+3.50 + -7.75 = -4.25 diopters



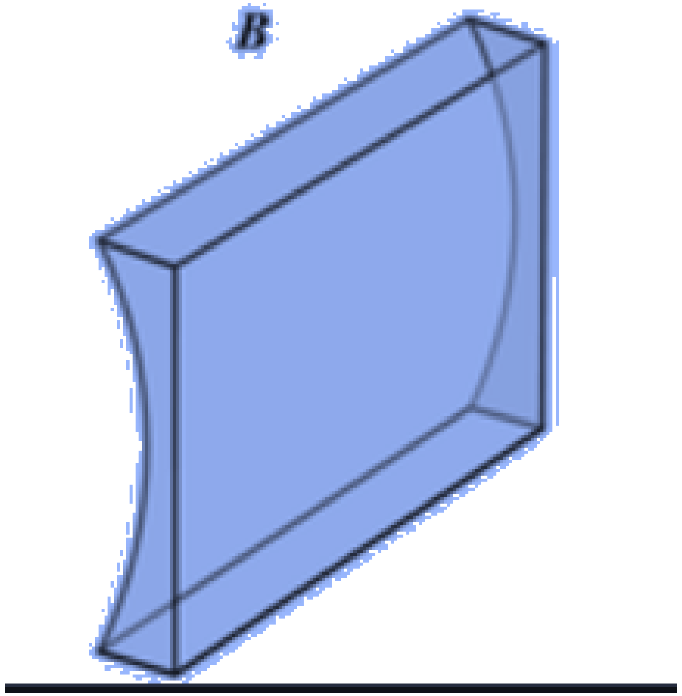
Optical Cross and Curves - Spherical

Cylinders



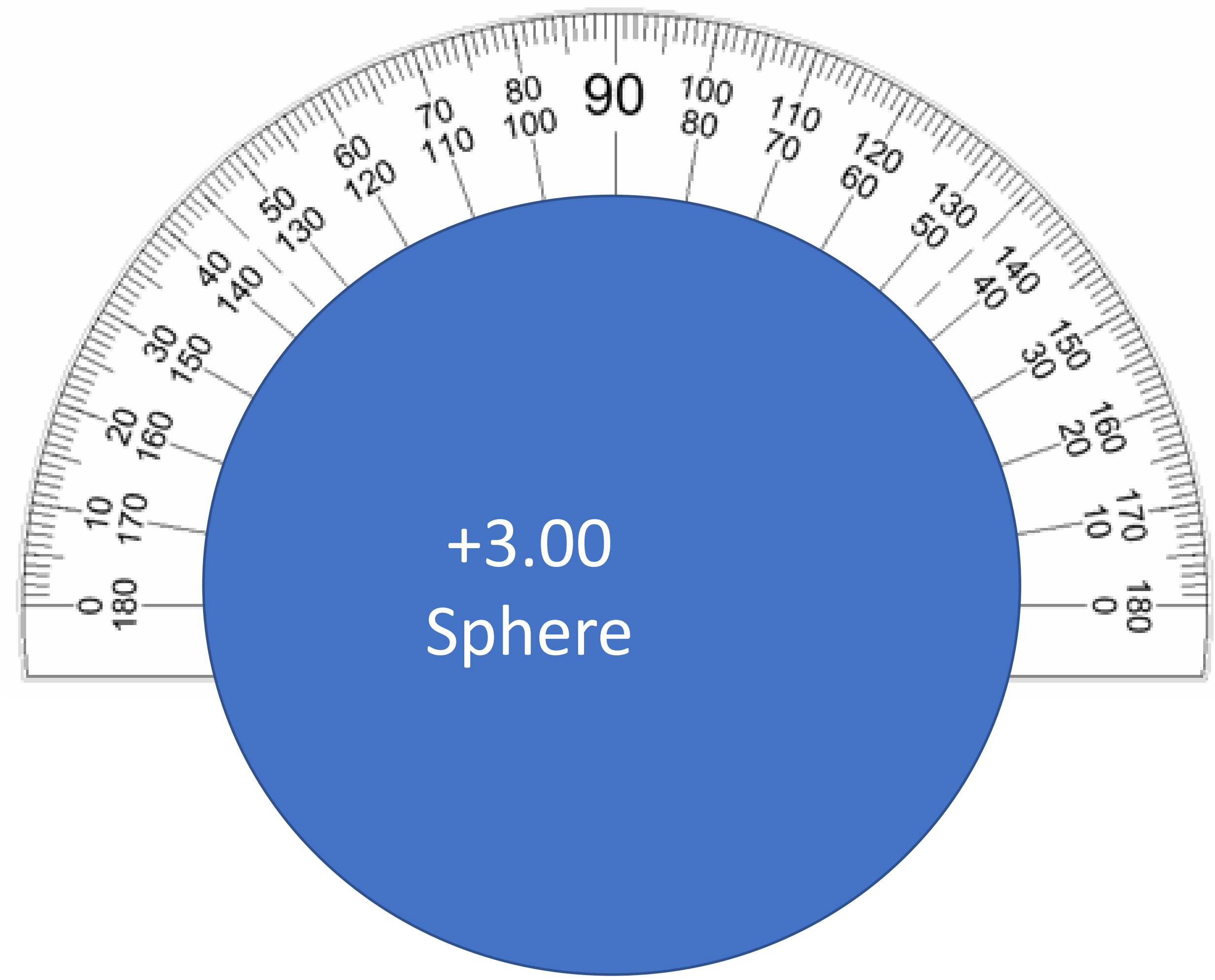


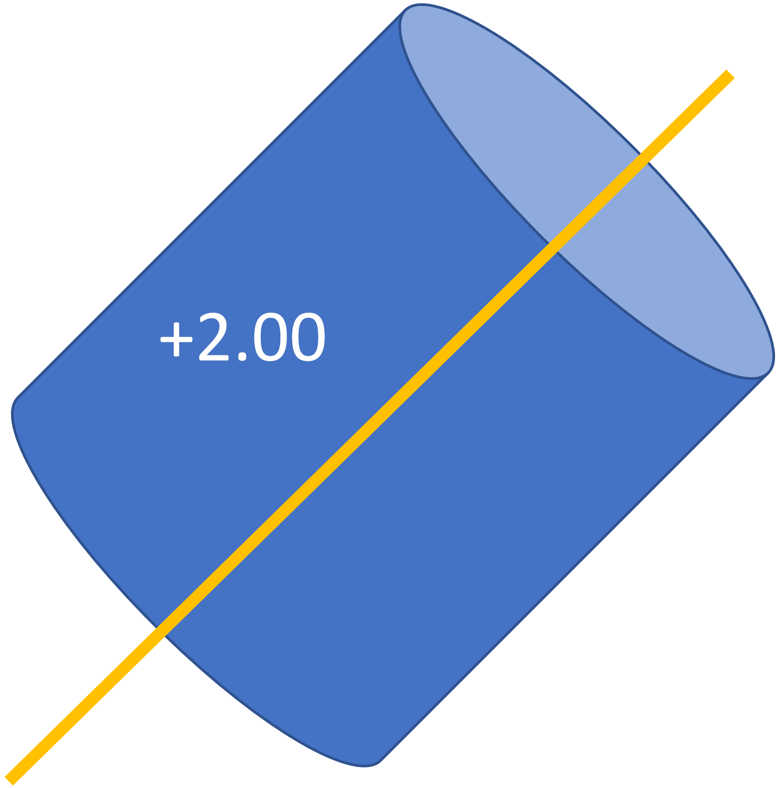
Plus Cylinder



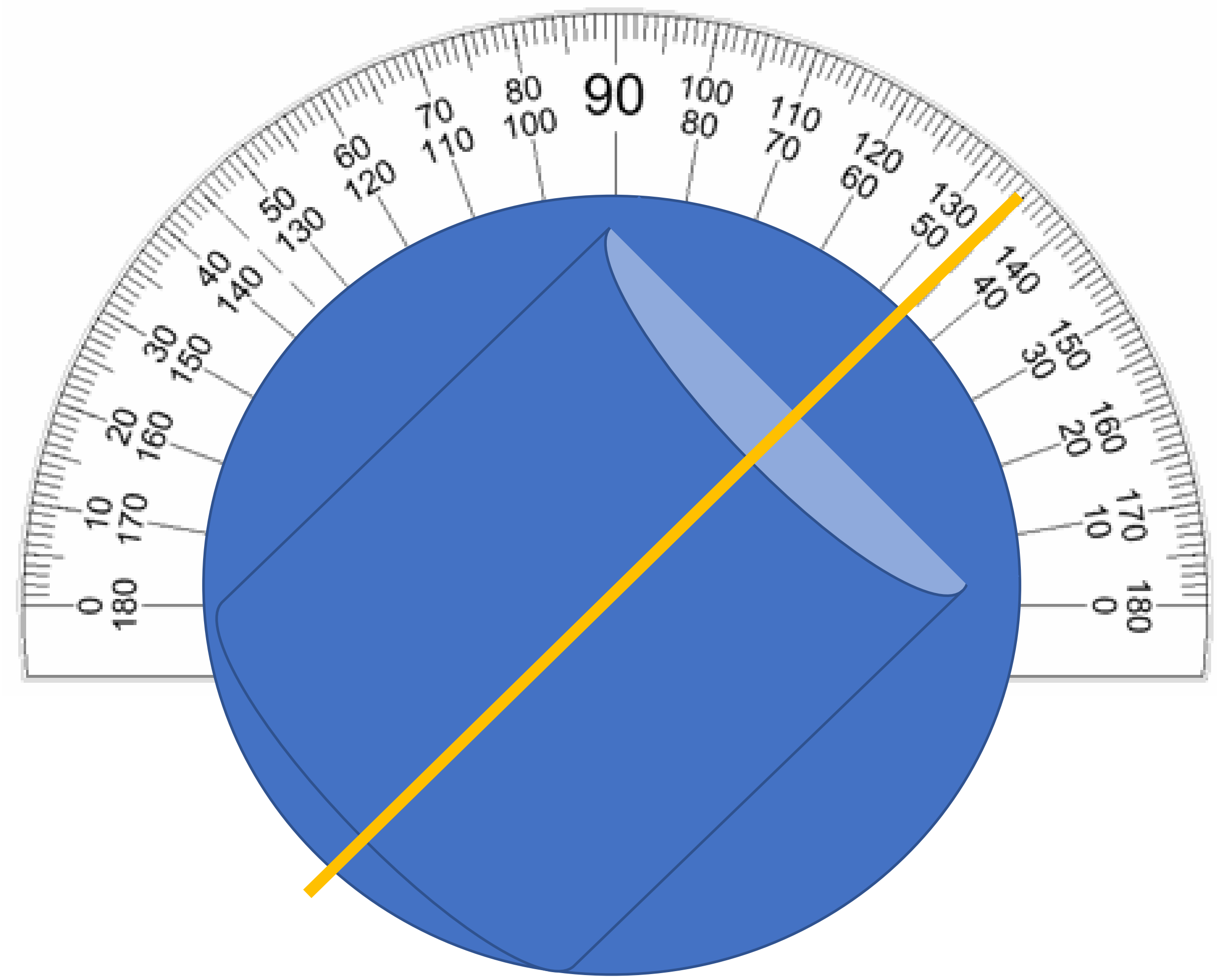
Minus Cylinder

Cylinders


0
180
10
170
20
160
30
150
40
140
50
130
60
120
70
110
80
100
90
100
80
110
70
120
60
130
50
140
40
150
30
160
20
170
10
180
0
+3.00
Sphere


+2.00

Cylinders



+3.00 +2.00 X 045

Cylinder Lens Clock Readings

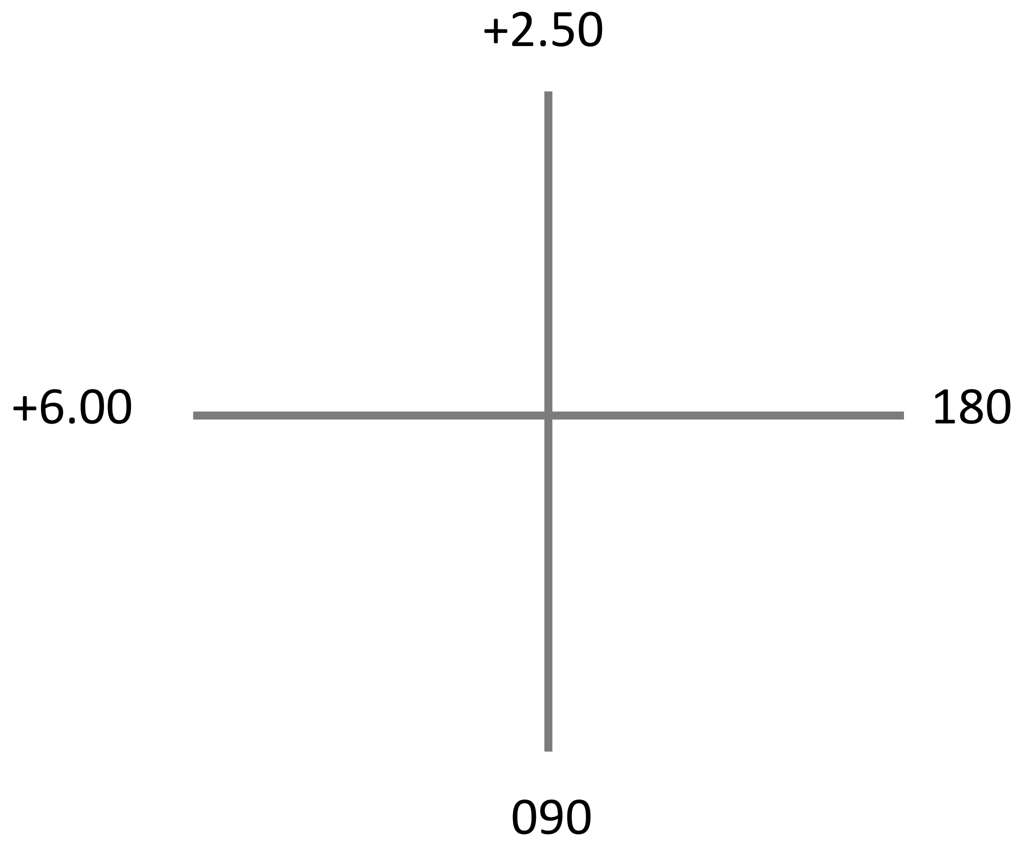
- The lens clock can be used to determine if there is a cylinder by reading the surface curves at 180 and 90 degrees.

- If there is a difference between the two meridians, there is a cylinder in the lens.

- Modern lenses are surfaced in minus cylinder form, so the front surface of the lens (F1) is always spherical in a non-aspheric design, while the back surface (F2) has differences in the meridians.

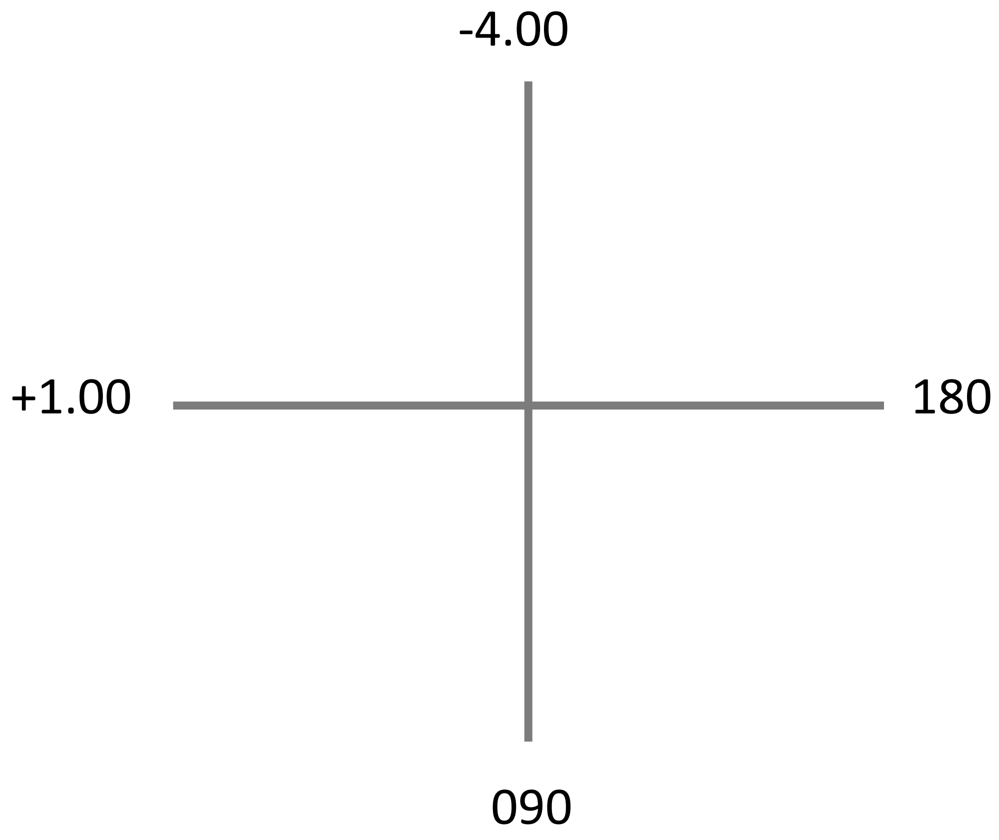
THE OPTICAL CROSS & TRANSPOSING

The Optical Cross



Sometimes, the total power is given to you on the cross, and you must determine the prescription.

Transposing With the Optical Cross



+1.00 @ 180
-4.00 @ 090

What is the Rx in Minus cylinder form?
+1.00 -5.00 x 180

What is the Rx in Plus cylinder form?
-4.00 +5.00 x 090

What type of astigmatism is this?
Mixed Astigmatism

Understanding Axis and Power

A cylindrical prescription just tells us how much power a patient is looking through along any given axis.

Degrees Away from Prescribed Axis	% of Cylinder Power is in Effect
0	0
30 / 150	25%
45 / 135	50%
60 / 120	75%
90	100%

Understanding Axis and Power

At the prescribed axis, you would remember the fitting cross along with your primary meridians and just transpose. This will give you the power at the axis and 90 degrees away.

Rx	Power in Prescribed Axis	Power 90 Degrees Away
+1.00 -0.50 x 180	+1.00	+0.50
+3.00 -0.25 x 180	+3.00	+2.75
-2.00 -0.75 x 090	-2.00	-2.75
+0.50 -1.00 x 090	+0.50	-0.50

+0.50 +0.50 x 090

Understanding Axis and Power

If you need power 45 and 135 degrees away, divide the cylinder by 2 and add it to the sphere.

Rx	Power 45 Degrees Away From Prescribed Axis	Power 135 Degrees Away From Prescribed Axis
+3.00 -1.00 x 045	+2.50	+2.50
-6.00 + 1.50 x 045	-5.25	-5.25
-0.75 +1.50 x 135	Plano	Plano

Understanding Axis and Power

Take the following prescription: -2.00 -1.00 x 030. How much power is at axis 180?

The Rx is 030 degrees from the 180 axis, so 25% of the cylinder power is in effect.

25% of -1.00 is -0.25

We add -0.25 to our sphere and get: -2.25 @ 180

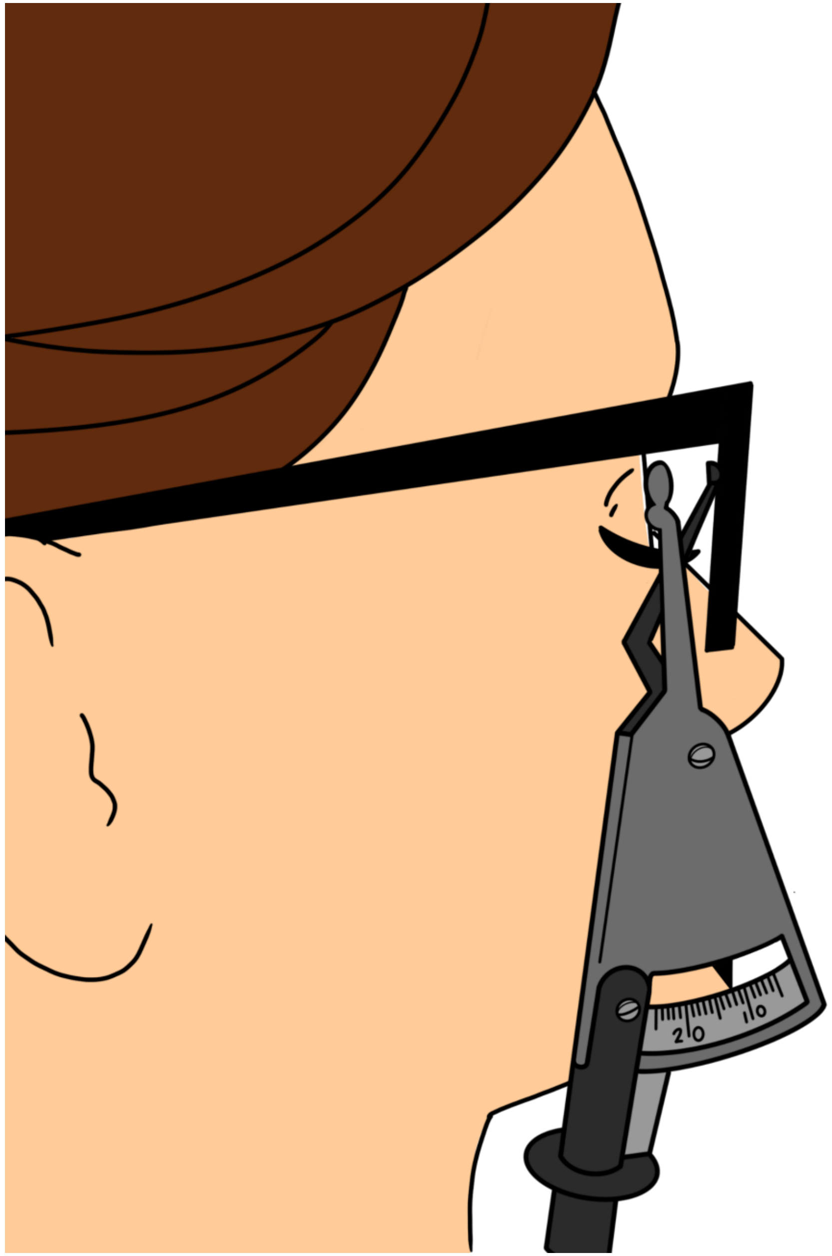
Take the following prescription: -5.00 +2.00 x 120. How much power is at axis 180?

The Rx is 060 degrees from the 180 axis, so 75% of the cylinder power is in effect.

75% of +2.00 is +1.50

We add +1.50 to our sphere and get: -3.50 @ 180

VERTEX DISTANCE



Vertex Distance

Vertex Distance is the straight-line measurement in millimeters from the back surface of any lens to the apex of the cornea.

This can be measured using a distometer.

Vertex Distance and Effective Power

Plus Lens

- Moved **closer** to the eye it **decreases** the effect of the power.
- Moved **away** from the eye it **increases** the effect of the power.

Minus Lens

- Moved **closer** to the eye it **increases** the effect of the power.
- Moved **away** from the eye it **decreases** the effect of the power

Vertex Distance and Effective Power

Effective Power = Refracted Power ∕ (1 + Change in Vertex Distance in M)(Refracted Power)

If a patient has an exam where their doctor refracted them @ 15mm, but their eyeglasses are fit @ 5mm, what is the effective power of the lens it the patient's Rx -15.00?

Refracted Power: -15.00
Refracted Vertex: 15mm
Fit Vertex: 5mm

Step 1: Plug numbers into the formula

$$-15.00 /(1 + (-0.010 \times -15.00))$$

The 0.010 is negative because the lens moves closer to the eye than where it was refracted.

Vertex Distance and Effective Power

Effective Power = Refracted Power ⁄ (1 - Change in Vertex Distance in M)(Refracted Power)

Step 2: Factor the part of the formula in parenthesis

So, we multiply -0.010 meters x -15.00 = 0.15

$$-15.00 /(1 - 0.15)$$

Step 3: Take care of the second set of parenthesis

$$1-0.15 = 0.85$$

$$-15.00 /(0.85) = -17.64$$