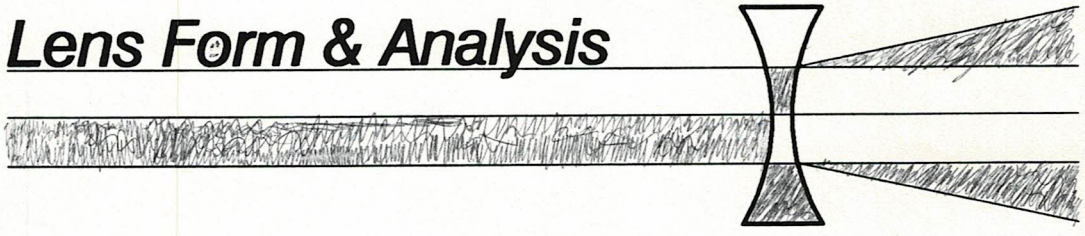
ABO PREPARATION

Week

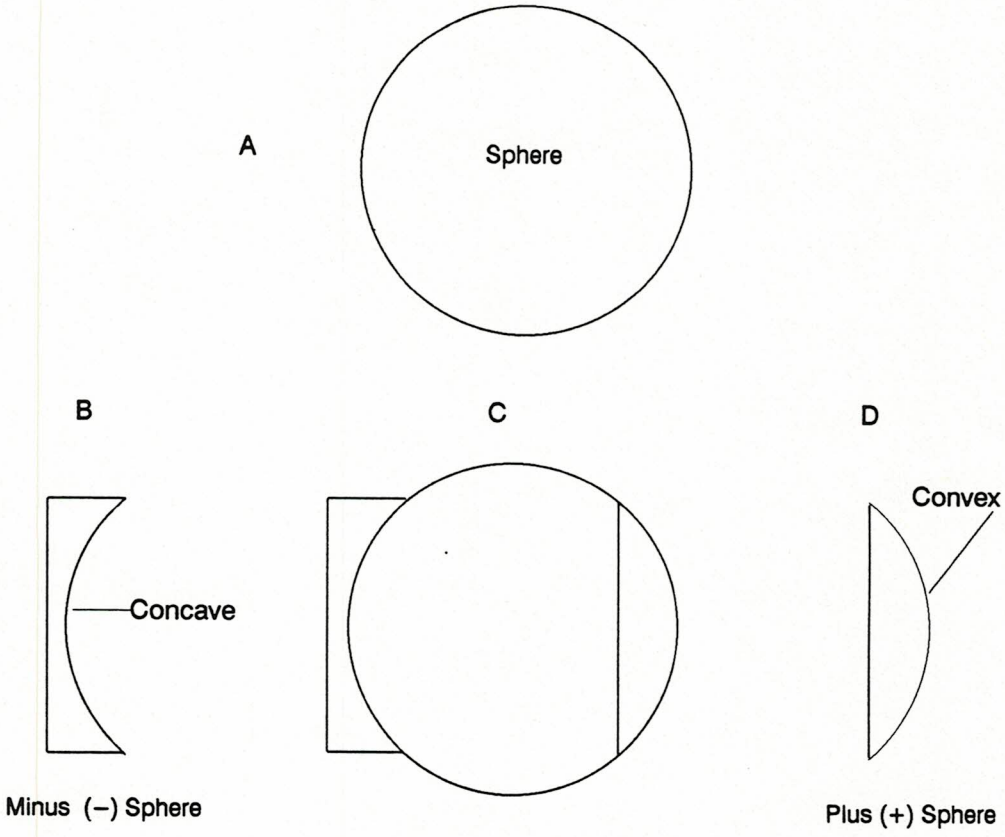
3

Lens Form & Analysis

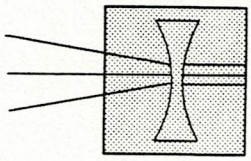


3: Lens Form & Analysis

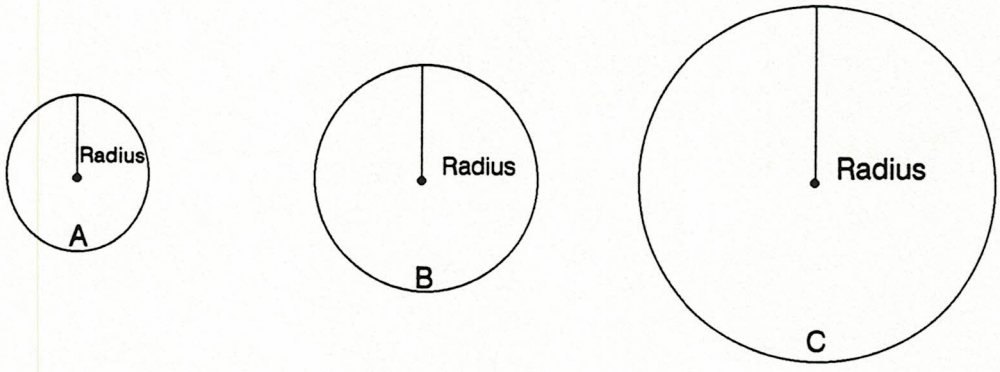
Spheres



Although it is useful to think of lenses as prisms base to base or apex to apex, in reality lenses are not angular in shape at all, rather they consist of curves. The basic curve upon which most ophthalmic lenses are shaped is the sphere. A sphere is a three dimensional geometric shape such as a round ball. As we know ophthalmic lenses are not round balls, however the curve on lenses can be, in fact, *part* of a sphere. Figure D above illustrates a sphere or ball in which a section has been cut off. The curve of the cut off section is a convex curve. Figure B shows a curve which would result if we were to take an "impression" of the sphere and its shape is concave. In optics, sign conventions have been established in which a convex curve is assigned a plus (+) sign, while concave surfaces are given a minus (−) sign. If a surface is perfectly flat it contains no curve at all and is called a "plane" or plano surface.



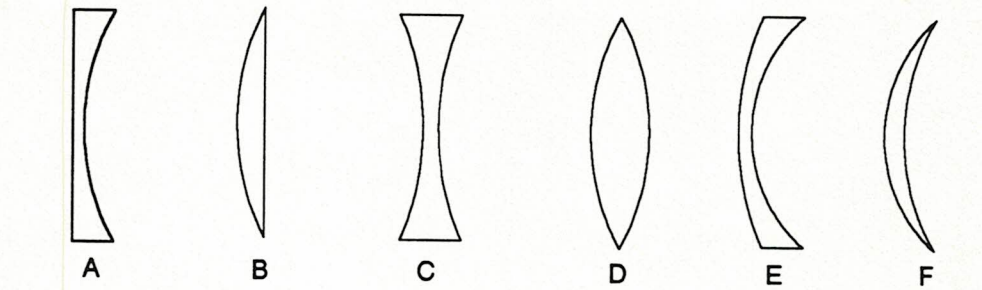
Radius Of Curvature

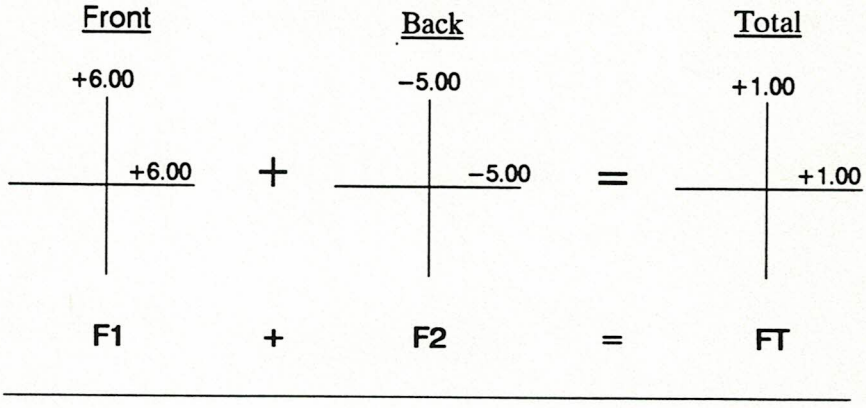


Larger Circle or Sphere	Smaller Circle or Sphere
Longer Radius of Curvature	Shorter Radius of Curvature
Flatter Curve	Steeper Curve
Less Power	More Power

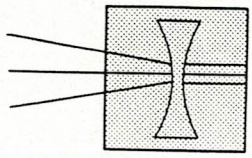
Every circle or sphere has a radius of curvature. The radius of curvature is simply the distance from the geometric center of the circle to its periphery where the line is drawn. As the radius of curvature becomes longer the circle gets larger. As the circle gets larger, its curve gets flatter, as the curve gets flatter on a transparent material such as a lens, the power in diopters of that *surface* becomes less. The table above summarizes this relationship. Another factor which influences the power of any given transparent surface is the material from which it is made. As we saw in Part 2 of this course, denser materials, that is those with a higher index of refraction, will cause light to slow down more than less dense materials with a lower index of refraction. Therefore, if the surfaces of two lenses have the same radius of curvature, but are made with different materials with different indices of refraction, the surface with the higher index will be more powerful. This explains why higher index lens materials are popular for use with stronger prescriptions. Higher index materials can achieve the same power using flatter curves which result in thinner lenses. Why aren't all lenses made from higher index materials? That will be explained later in this course when we specifically cover lens material and multifocal designs.

Lens Shapes



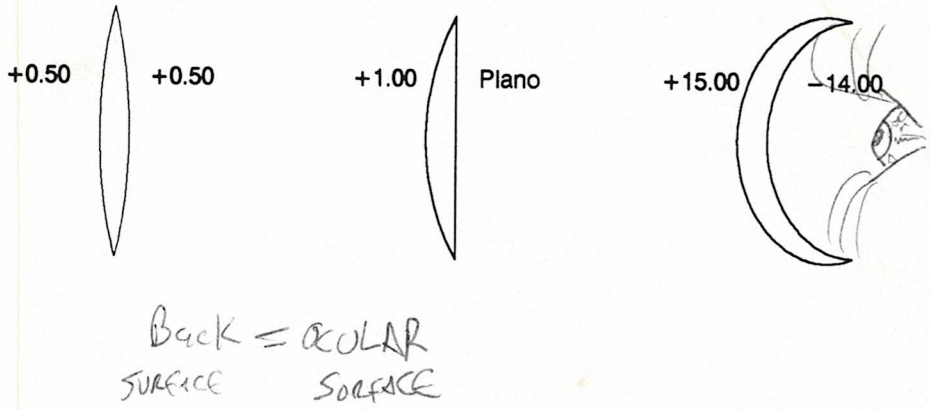


A spherical lens consists of two spherical surfaces– a front surface, and a back surface. A lens can assume many shapes as illustrated in figures A thru F above. The optical cross is useful for illustrating the power of each lens surface and the resultant total power. Since we are now dealing only with spherical surfaces, the power of each surface will be the same in all directions. Later in this section we will use the optical cross to illustrate cylindrical lenses as well. To determine the total power of a thin lens in air (most ophthalmic lenses are technically considered thin and of course they are usually surrounded by air) simply add the front surface power to the back surface power algebraically by applying the formula: F1 + F2 = FT where F1 = the power of the front surface, F2 = the power of the back surface, and FT = the total power of the lens. For example, if the front surface power of a given lens is a +6.00 diopter sphere, and the back surface power is a −5.00 diopter sphere, the total power of that lens would be a +1.00 diopter sphere. Expressed mathematically: +6.00 −5.00 = +1.00.

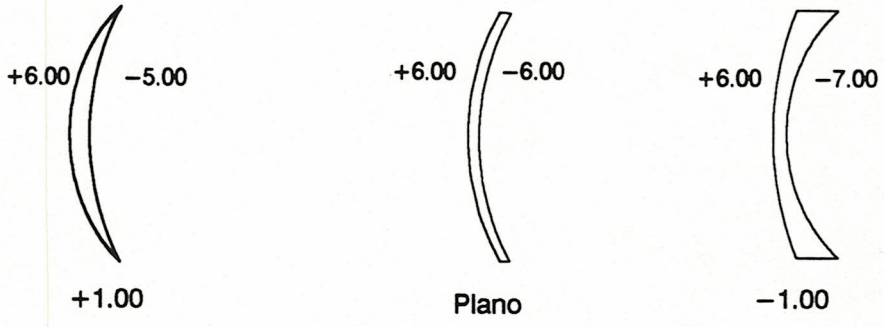


Corrected Curve Lenses

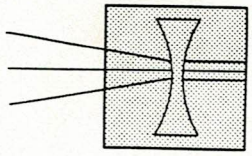
Some Possible Shapes Of a +1.00 Sphere



By applying the formula F1 + F2 = FT, it becomes evident that any given powered lens may take on a virtually infinite number of shapes and still produce the desired power. The illustration above shows just a few examples of what shapes a simple +1.00 spherical lens could possibly assume.



There are certain aberrations or distortions inherent in any lens with power. Most spectacle lenses made today are shaped so that these aberrations are minimized. These are known as *corrected curve lenses.* Corrected curve lenses are designed so that the back surface, also called the *ocular* surface, is as close to −6.00 D as can be reasonably expected given the power called for. As lenses increase in plus power, the ocular surface generally gets flatter, while stronger minus lenses are shaped with steeper back curves. As the eye rotates in various directions, a −6.00 D back curve allows the distance from the eye to the back of the lens to remain relatively consistent.

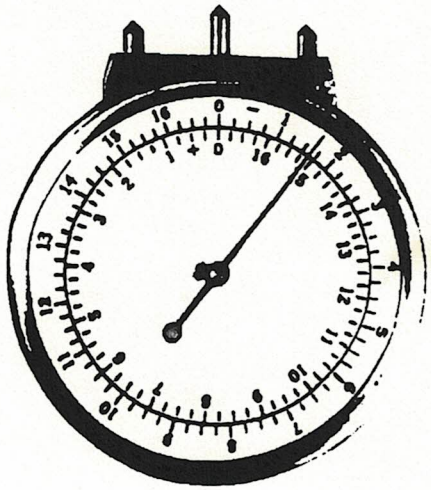


Base Curves

Power Range	Base Curve
+12.25 and over	+16.00
+10.75 ---------- +12.25	+14.00
+9.00 ---------- +10.50	+12.00
+5.50 ---------- +8.75	+10.00
+2.25 ---------- +5.25	+8.00
Plano ---------- +2.00	+6.00
Plano ---------- −1.75	+6.00
−2.00 ---------- −4.50	+4.00
−4.75 ---------- −8.00	+2.00
−8.00 ---------- −9.00	+1.25 or +0.50
−9.00 and over	Plano or minus base curve

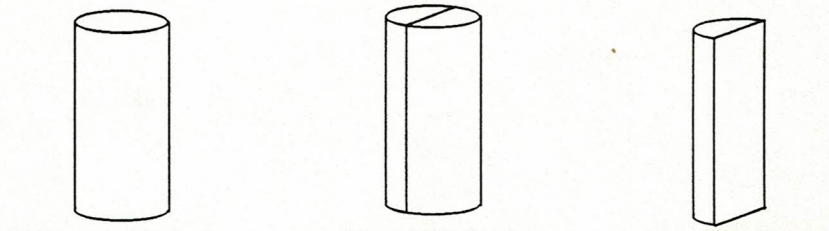
The base curve is always found on the side of the lens which contains the bifocal segment. In today's industry, that means the front surface almost all the time. The base curve chart illustrated above contains very general information and you should memorize its contents for ABO Exam purposes. More detailed charts are available from your laboratory or lens manufacturer. Note that powers which fall around plano up to about +/− 2.00 diopters are designed on a +6.00 D curve. As the powers increase in plus, the curves gradually get steeper, while the base curves of minus lenses gradually become flatter with increasing power. Base curve charts are designed to be guides. The recommended base curve for any given prescription can vary from one laboratory or manufacturer to another, especially on the "borderline" prescriptions. The importance of consistently measuring and specifying base curves cannot be overemphasized. Lens curves can be measured with a lens measure or "lens clock" as illustrated on the next page.

Lens Measure



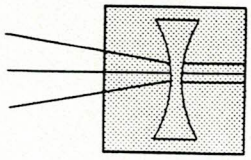
The lens measure, or lens clock, is used to measure the dioptric power of lens surfaces. It will typically contain two scales, one for measuring plus surfaces, and the other for minus. The lens measure calculates the surface power as if it were made of a material with an index of refraction of 1.530, which is the "standard" index of refraction in the optical industry. This is one of the most important yet most underrated tools in the optical dispensary. Many remakes can be avoided when this intrument is used on a routine basis with each and every patient.

Cylinder

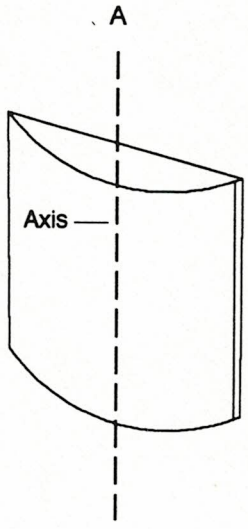


Transparent Cylinder | Slice Off A Section | Resultant Shape

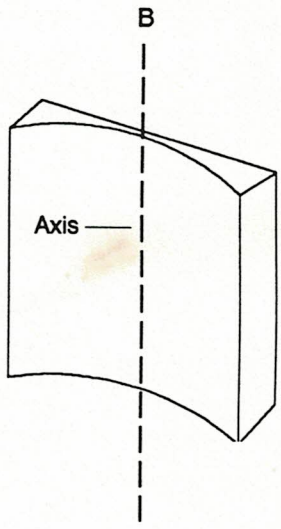
Up to this point we've discussed prism, determined that an ophthalmic lens can be perceived as a series of prisms either base to base or apex to apex, and we've shown how lens surfaces are actually curved in shape rather than angular. The shape mentioned so far is the sphere. However, most lenses also contain another shape, the *cylinder.* The cylinder, which is used for the correction of astigmatism, can be used by itself or it can be combined with a sphere.



Cylinder Axis

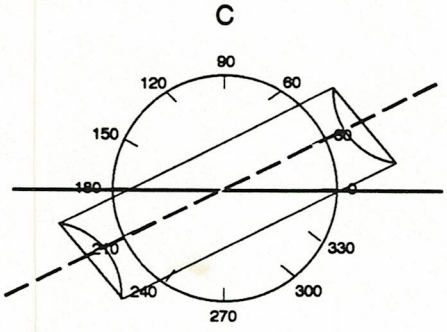


Plus Cylinder



Minus Cylinder

A cylindrical shape is flat in one direction and curved in the other. As we now know, it is the curve of a lens that gives it its power. Therefore the direction of the cylinder with no curve also contains no power and is called the *cylinder axis.*



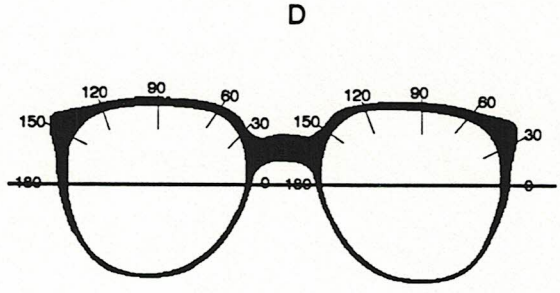
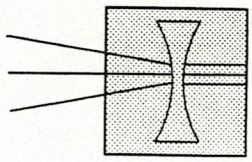
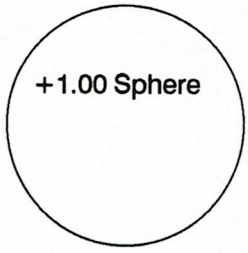


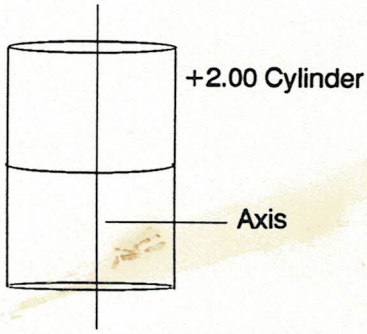
Figure C above shows a cylinder positioned on a protractor where the axis of the cylinder is positioned along the 30 degree meridian. If the power of the cylinder is +2.00D, we could say this was a plano sphere (since there is no spherical component here, only a cylinder) which is combined with a +2.00 diopter cylinder in which the axis is positioned along the 30 degree meridian. Since that's a lot to say, we use a shorthand notation to indicate the same thing: Pl + 2.00 x 30.

In a pair of spectacles, the orientation of the cylinder axis is determined as if a protractor were superimposed over each lens as indicated in figure D above.

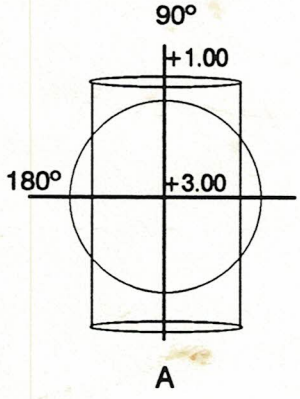


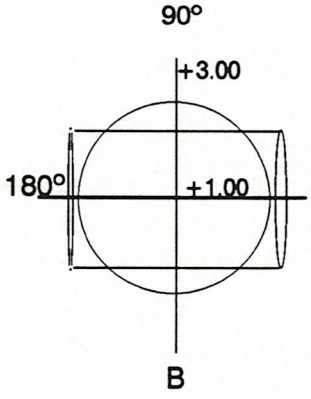
Compound Lenses

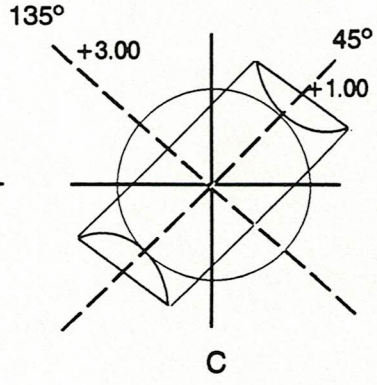




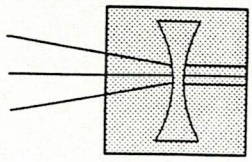
Most prescriptions which require cylinder also require a spherical component. This would apply in cases of compound myopic astigmatism and compound hyperopic astigmatism which we studied in Part 1. In these cases we combine a spherical lens with a cylinder to form a *compound lens.* The figure above shows a simple+1.00 D spherical lens and a +2.00 D cylinder. In the illustrations below, we have combined the two lenses into one. Figure A shows the cylinder axis oriented along the 90 degree meridian, in figure B the axis is at 180 degrees, and figure C shows the axis at 45 degrees. In each case the compound lens is superimposed upon an optical cross.



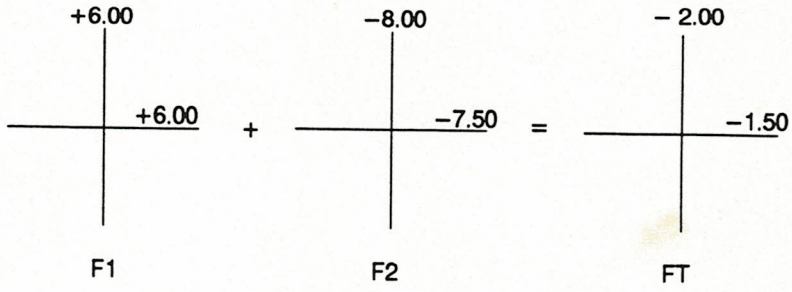




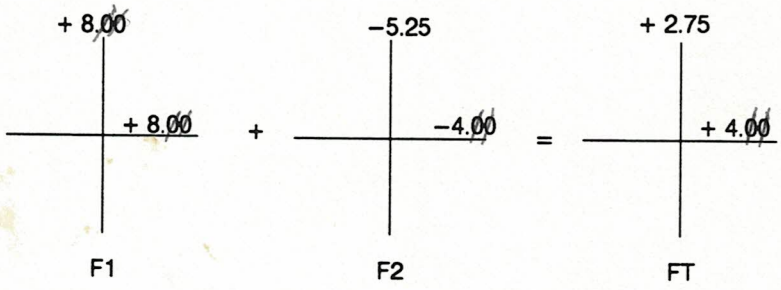
Remember, we started with a +1.00 sphere and then combined it with a +2.00 cylinder. The power of our new compound lens, therefore, will be a combination of the two. In example A above, the power of the compound lens in the 90° meridian is still equal to +1.00 D since the axis of the cylinder is oriented in that direction and there is no power along the axis of a cylinder. Along the 180° meridian, however, the power of the lens is +3.00D. This is because the full +2.00 D of cylinder power is in effect and we must add this power to the original +1.00 diopter of spherical power. So +2.00 + 1.00 = +3.00. This prescription would be written: +1.00 + 2.00 x 90, or +3.00 - 2.00 x 180. Study examples B and C above to see how the power in the various meridians of the compound lens changes as the axis of the cylinder changes.



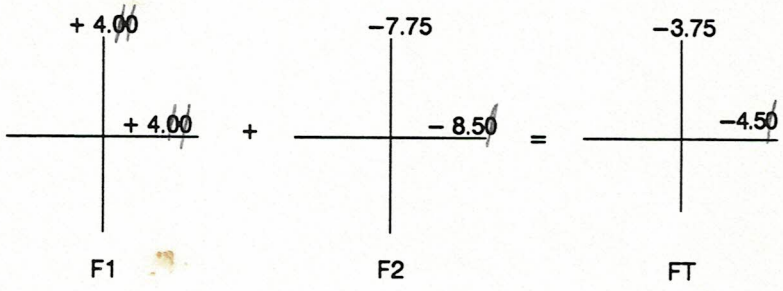
Power Cross



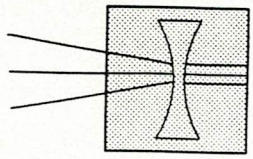
Rx: − 1.50 − 0.50 x 180; Base Curve = +6.00



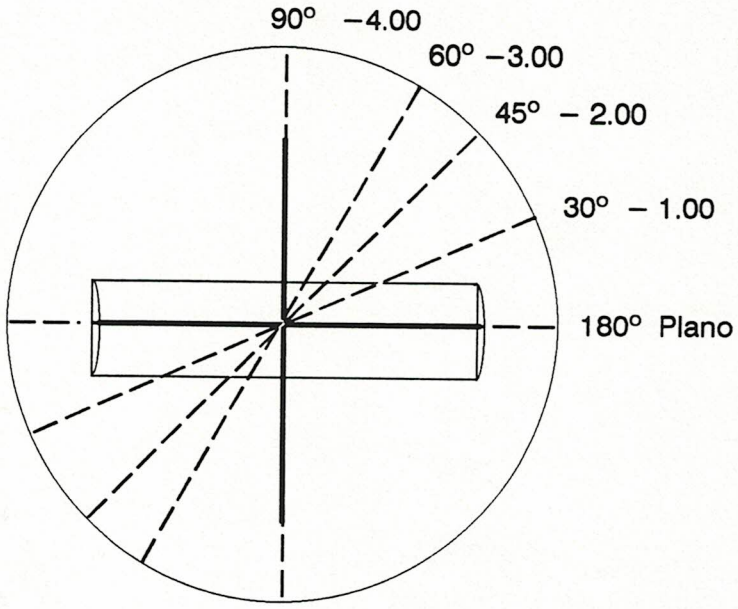
Rx: +4.00 − 1.25 x 180; Base Curve = +8.00



Rx: − 3.75 − 0.75 x 90; Base Curve = +4.00

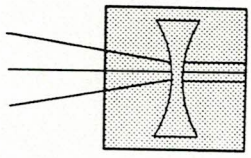


Power Of A Lens In Various Meridians



As we demonstrated, the power of a cylindrical lens changes along its various meridians as the axis of the cylinder changes. It is possible to determine the power of a lens in any meridian. For our purposes, we are primarily concerned with finding the powers of a lens along the 90 ° and 180° meridians when the given prescription axis is at either 90°, 180°, or 45°. Of course, the axis of a prescription lens may fall anywhere between 0−179°, but for the purposes of succeeding on the ABO exam, it is most important to know the three axis mentioned above. The figure above shows the powers in various meridians of a − 4.00 cylinder with the axis positioned along the 180° meridian. The chart below summarizes the percentage of cylinder power along the various meridians.

Degrees Away from Cylinder Axis	% of Cylinder Power in Effect
0	0
30	25
45	50
~~60~~ 60	75
90	100



Power In The 180° and 90° Meridians

When the cylinder axis is at 180° or 90°:

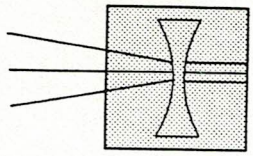
Rx:	Power in 180	Power in 90
+1.00 –0.50 x 180	+1.00	+0.50
– 2.00 – 0.75 x 180	– 2.00	– 2.75
+ 3.00 –0.25 x 180	+ 3.00	+ 2.75
+ 2.25 +2.25 x 90	+ 4.50	+ 2.25
+ 2.00 – 0.75 x 90	+ 1.25	+ 2.00
+ 0.50 – 1.00 x 90	– 0.50	+ 0.50

The first number of a prescripton indicates its spherical component, the second number indicates the power of the cylinder, while the third number indicates the meridian along which the cylinder axis lies. Therefore, the first number is also equal to the power of the lens along the axis of the cylinder. The first nuimber in the first example in the chart above is + 1.00. Since the axis is at 180°, the power of that lens in the 180 meridian is equal to + 1.00. To determine the power of the lens ninety degrees away from the cylinder axis, simply algebraically add the sphere power to the cylindrical power. In this same example we add + 1.00 –0.50 = +0.50 and ninety degrees away from the axis puts us at 90°.

When the cylinder axis is at 45° or 135°:

When the cylinder axis of a given prescription is at 45° or 135°, and you need to find the power of that lens either in the 90° or 180° meridian, cut the cylinder in half and add it to the sphere.

Rx	Power in 180	Power in 90
+ 3.00 – 1.00 x 45	+ 2.50	+ 2.50
– 6.00 + 1.50 x 45	– 5.25	– 5.25
–0.75 +1.50 x 135	Plano	Plano



Transposition

How to Transpose A Prescription:

1. Change the sign of the cylinder
2. Add the the first two numbers together algebraically
3. Change the cylinder axis by 90° so the new number falls between 1–180 degrees.

Examples:

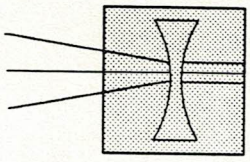
Original Rx	Transposed
+ 2.50 – 0.75 x 180	+ 1.75 + 0.75 x 090
+ 4.00 – 0.25 x 180	+ 3.75 + 0.25 x 090
+ 3.00 – 1.00 x 045	+ 2.00 + 1.00 x 135
– 2.25 – 0.50 x 030	– 2.75 + 0.50 x 120
– 3.00 + 2.50 x 010	– 0.50 – 2.50 x 100
– 3.75 + 1.25 x 060	– 2.50 – 1.25 x 150
– 0.50 + 0.75 x 175	+ 0.25 – 0.75 x 085
– 2.50 + 0.50 x 005	– 2.00 – 0.50 x 095
+ 9.50 – 2.75 x 090	+ 6.75 + 2.75 x 180
– 11.25 + 300 x 040	– 8.25 – 3.00 x 130

Exercises:

Transpose the following prescriptions:

1) +125 +100 x 090
2) +325 +050 x 090
3) +125 +675 x 130

1) + 2..25 – 1.00 x 180 +125 +100 x 090
2) + 3.75 – 0.50 x 180
3) + 2.00 – 0.75 x 040
4) – 3.00 – 0.25 x 035
5) – 4.50 + 1.75 x 015
6) – 6.00 + 2.25 x 050
7) – 0.25 – 0.25 x 090
8) + 3.25 + 1.25 x 175
9) + 9.25 – 3.50 x 005
10) – 12.50 + 1.75 x 010



Vertex Distance

Figure A: +10.00 D Lens
Vertex Distance = 13 mm
Light Focuses On Retina
Correct Power for this patient at this vertex distance

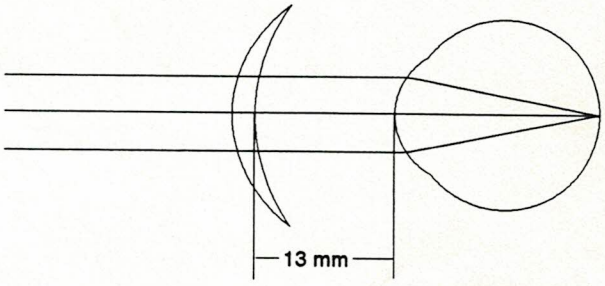


Figure B: + 10.00 D Lens
Vertex Distance = 18 mm
Effective Power = + 10.50
Compensated Power = +9.50

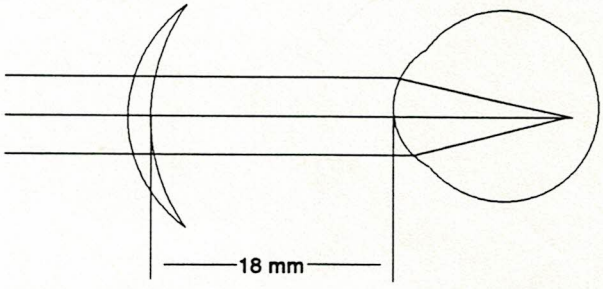
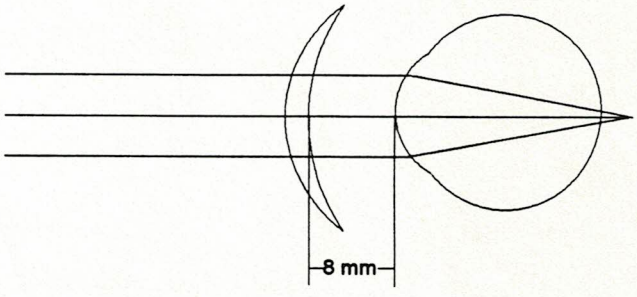


Figure C: + 10.00 D Lens
Vertex Distance = 8 mm
Effective Power = + 9.50
Compensated Power = +10.50



The distance from the front of the cornea to the ocular surface of the lens is called the *vertex distance*. As a spectacle lens with power is moved either closer to or farther away from the eye, the position of its focal point, relative to the eye, also changes. As the relative position of the focal point changes, *the effective power* of the lens is changed. As the effective power of the lens changes, its ability to correct any given ametropia is effected. Although the effective power of any lens with power will change with variations in vertex distance, *the changes are only significant in lens powers which exceed ± 7.00 diopters.*

Rule of Thumb: The effective power of a 10.00 diopter lens moved a distance of 5 mm will change by approximately 0.50 diopters. Whether the power changes by ±0.50 diopters will depend upon the sign of the lens as well as the direction it was moved. Please refer to the illustrations above along with the taped discussion.

ABO PREPARATION COURSE

3: Lens Form & Analysis

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