Advanced Optics, Through the Looking Glass

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International Speaker & Author

About the Speaker

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- Master in Ophthalmic Optics
- Master in Business Administration
- Bachelor of Science in Business
- Associate of Science in Opticianry
- ABO Certified
- NCLE Certified
- Author of text-book, *Pure Optics*
- Joe Bruneni Award in Optics, Association of Schools Colleges of Optometry
- Beverly Meyers Achievement Award in Ophthalmic Optics

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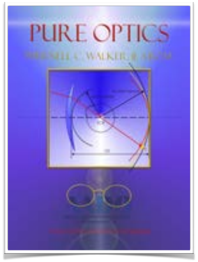
References:

Pure Optics

by

Phernell Walker, II, MBA, ABOM



Objectives:

- Geometric Optics
- Position of Wear Optics and Ophthalmic Lenses
- Optical Design Considerations
- Q & A

Lens Power

Magic Combinations:

- Base Curve (front vertex power)
- Ocular Surface (anterior vertex power)
- Lens Thickness (measured in meters)
- Refractive Indice

Approximate:

$$D_1 + D_2 + (t)\,(D_1)^2 / n = D_e$$

Exact:

$$[\,D_2 / 1-(t/n)\,(D_2)\,] + D_1 = D$$

Key:

- D_1 = Base Curve
- D_2 = Ocular Curve
- t = Thickness (M)
- n = Refractive Index
- D_e = Total Dioptric Power
- 1 = Constant

Lights Camera Action

A lens has a base curve of +9.00D, Ocular curve of -2.00D, 7mm thick and is made of plastic 1.60n.

What is the lens power the patient will experience?

$$D_1 + D_2 + (t)\ (D_1)^2 / n = D_e$$

"The Envelope Please"

Tada....

$$\mathbf{D_1 + D_2 + (t)\ (D_1)^2 / n = D_e}$$

$$+9.00 + -2.00 + (7mm)\ (9.00)^2 / 1.60 = D_e$$
$$+7.00 + (.007m)\ (81) / 1.60 = D_e$$
$$+7.00 + .567 / 1.60 = D_e$$
$$+7.00 + .35 = D_e$$
$$\mathbf{+7.35 = D_e}$$

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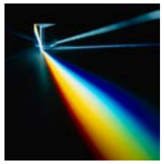
Resolving and Resulting Prism

Prism can be written in either:

- Rectangular (Resolving Prism)
- Polar Coordinate (Resultant)



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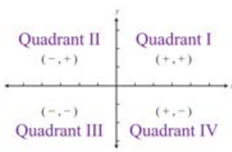
Prism Rectangular Form

So far, we have reviewed prism orientation in rectangular form:

- B.I.,
- B.O.
- B.U.
- B.D.
- Combination



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Rectangular Prism Notation

Polar coordinate prism notation indicates the base direction in degrees. There may be times when you will need to convert between rectangular and polar coordinate prism form.

This can be most useful when neutralizing lenses (determining the unknown power of a lens) with a lensometer.

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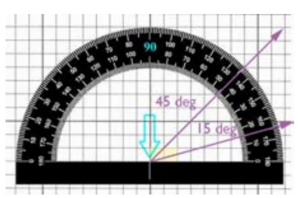
Polar to Rectangular Prism Conversion



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Polar Notation to Rectangular

$V = (D_e)$ (sine a)

$H = (D_e)$ (cosine a)

V = Vertical Coordinate
H = Horizontal Coordinate
D_e = Power of Prism

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Polar to Rectangular Prism Conversion

Example:

Convert the following prescription from polar notation to rectangular notation:

O.D.+3.25 DS, 4 Prism, B.I. @ 045

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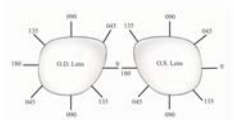
Solution:

OD: +3.25 DS, 4^Δ BI @ 045

V = (4.00) (.707)
H = (4.00) (.707)
V = 2.82
H = 2.82

OD: +3.25, 2.82^Δ B.U., 2.82^Δ B.I.Notice the rectangular coordinates for the right eye directly corresponds with the polar coordinate of 045 degrees (fig. 11-5).



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Resultant Prism

When generating prescriptions and creating prism in an optical lab, it is important to know the exact location of the prism's base.

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Rectangular to Polar Notation

$\sqrt{P} = H^2 + V^2$

$\tan^{-1} a = V / H$

where:

$\sqrt{P}$ = prism (square root of the prism)
V^2 = vertical coordinate
H^2 = horizontal coordinate

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Resultant Prism

Example:

Convert the prescription:

OD +3.00 DS, 4 Prism B.I. & 2 Prism B.U. from rectangular to polar prism:

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$\sqrt{P} = H^2 + V^2$

$\sqrt{P} = 4^2 + 2^2$

$\sqrt{P} = 16 + 4$

$\sqrt{P} = 20$

$\sqrt{P} = 4.47\ D^{\Delta}$

$\tan^{-1}\ a = V / H$

$\tan^{-1} a = 2 / 4$

$\tan^{-1} a = .50$

Converted Rx: +3.00 DS, 4.47 D^{Δ} @ 27 degrees

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Objects Appear Skewed

Rx:

OD: -8.50 DS

OS: -8.50 DS

- Pantoscopic Tilt = 15 deg
- n = 1.498 (Cr-39)
- Vertex = 13mm

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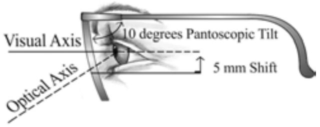
Martin's Tilt Formula



Mastering Optics with Formulas

$S_{De} = S\ [1 + (\sin @)^2 / 2n]$

$C_{De} = S_{De}\ (\tan @)^2$

Variable Key:

S_{De} = effective sphere power

S = sphere power

n = refractive index

C_{De} = effective cylinder

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Step I: $S_{De} = S\ [1 + (\sin @)^2 / 2n]$

$S_{De} = S\ [1 + (\sin @)^2 / 2_n$

$S_{De} = -8.50\ [1 + (\sin 15)^2 / 2\ (1.498)]$

$S_{De} = -8.50\ [1 + .06698 / 2.996]$

$S_{De} = (-8.50)\ (1 + .02235)$

$S_{De} = (-8.50)\ (1.02235)$

$S_{De} = -8.68$

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Step II: $C_{De} = S_{De}$ (tan@)^2

C_{De} = -8.68 (tan15)^2
C_{De} = -8.68 (tan15)^2
C_{De} = (-8.68) (tan15)^2
C_{De} = (-8.68) (tan15)^2
C_{De} = (-8.68) (0.26759)^2
C_{De} = (-8.68) (0.7160441)

C_{De} = 0.716

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Lens Tilt Resultant Rx

Original Rx:

OD: -8.50 DS
OS: -8.50 DS

Resultant Rx:

-8.68 -0.72 x 180

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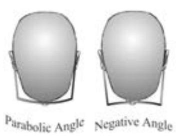
I Feel Nauseous

Rx:
OD: -6.00 -1.00 x 180
OS: -6.00 -1.00 x 180

- Parabolic Angle = 20 deg
- n = 1.70
- Vertex = 13mm



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Step I: Convert Rx to the 090th Meridian

Rx:
OD: -6.00 -1.00 x 180
OS: -6.00 -1.00 x 180

Rx:
OD: -7.00 +1.00 x 090
OS: -7.00 +1.00 x 090

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Step I: $S_{De} = S\,[1 + (\sin @)^2 / 2n]$

$S_{De} = S\,[1 + (\sin @)^2 / 2n$

$S_{De} = -7.00\,[1 + (\sin 20)^2 / 2\,(1.70)]$

$S_{De} = -7.00\,[1 + 0.1169 / 3.40]$

$S_{De} = (-7.00)\,(1 + 0.034)$

$S_{De} = (-7.00)\,(1.034)$

$S_{De} = -7.23$

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Step II: $C_{De} = S_{De}\,(\tan @)^2$

$C_{De} = -7.24\,(\tan 20)^2$
$C_{De} = -7.24\,(\tan 20)^2$
$C_{De} = (-7.24)\,(\tan 20)^2$
$C_{De} = (-7.24)\,(\tan 20)^2$
$C_{De} = (-7.24)\,(0.36397)^2$
$C_{De} = (-7.24)\,(0.13247)$

$C_{De} = +0.96$

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Lens Tilt x 180 Resultant Rx

Original Rx:

OD: -6.00 -1.00 x 180
OS: -6.00 -1.00 x 180

Original (Transposed) to 090th Meridian:
OD: -7.00 +1.00 x 090
OS: -7.00 +1.00 x 090

Resultant Effective Rx:

Answer: -7.28 +1.96 x 090

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Magnification

- base curve
- lens dioptric power
- thickness
- vertex distance
- refractive index

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Spectacle Magnification

$M_S = 1 / (1- (t) (D_1)) / n$
$M_P = 1 / (1 - D_e (h_m))$
$(M_S) (M_P) = M_T$
$(M_T -1)$ 100 = % of X

M_S = magnification shape
M_P = magnification power
M_T = total magnification

Practice Makes Perfect

A patient has the following prescription & fitting parameters:

- SV Lenses
- 1.66_n
- Vertex (h) = 13mm
- BC: +2.00D

What is the percentage of spectacle magnification?

O.D. -8.75 D.S. (thickness 5mm)
O.S. -6.00 D.S. (thickness 4mm)

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Calculate Magnification Shape

OD Lens Only:

$M_S = 1 / 1 – (t/n) (D_1)$
$M_S = 1 / 1 – (.005/ 1.66) (2)$
$M_S = 1 / 1 – (.003) (2)$
$M_S = 1 / 1 – 0.006$
$M_S = 1 / 0.994$
$M_S = 1.006$

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Calculate Magnification Power

OD Lens Only:

$M_P = 1 / 1 – (h_m) (D)$
$M_P = 1 / 1 – (.013)(-8.75)$
$M_P = 1 / 1 - .113$
$M_P = 1 / -0.887$
$M_P = 1.127$

Shape x Power

OD Lens Only:

M% = [(M_S) (M_P) -1] 100
M% = [(1.006) (1.127) - 1] 100
M% = [1.133-1] 100
Answer: **M = 13.38%**

(Minus Lenses equal 13.38% demagnification)

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Calculate Magnification Shape

OS Lens Only:

M_S = 1 / 1 – (t /n) (D_1)
M_S = 1 / 1 – (.004/ 1.66) (2)
M_S = 1 / 1 – (.002) (2)
M_S = 1 / 1 – .004
M_S = 1 / -0.996
M_S = 1.004

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Calculate Magnification Power

OS Lens Only:

M_P = 1 / 1 – (h_m) (D)
M_P = 1 / 1 – (.013) (-6.00)
M_P = 1 / 1 - .078
M_P = 1 / -0.922
M_P = 1.084

Shape x Power

OS Lens Only:

M% = [(M_S) (M_P) -1] 100
M% = [(1.004) (1.084) - 1] 100
M% = [1.088 - 1] 100
Answer: **M = 8.83%** (demagnification)

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Aniseikonia

OD = 13.38% demagnification
OS = 8.83% demagnification

Delta = 4.55%

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Phernell's Index Rule

What is the refractive index of a lens if the prescription reads –5.00 D.S. in the lensometer, the base curve measures +2.00 and the ocular curve measures –5.50 using a lens clock calibrated for 1.530_n?

Phernell's Index Formula

Minus Power:
$(D_1 + D_2) / (1.530_n - 1)(D_e + 1) = n$

Plus Power:
$(D_1 + D_2) / (1.530_n - 1)(D_e - 1) = n$

Phernell's Index Rule

D_1 Base curve (front curve)

D_2 Ocular curve (back curve)

1.530_n Calibrated lens clock

1 Constant

D_e Lens dioptric power or spherical equivalent

n Refractive index

Example of Formula Notation Method

Step I

Using a lensometer, neutralize the total dioptric power of the lens. If cylinder power is present, calculate the ***spherical equivalent*** (50% of the cylinder added to the sphere power) as the total dioptric power.

Step II

Using a lens clock, measure the base curve. This becomes D_1.

Phernell's Index Rule

$$+2.00 + -5.50 / [(1.530_n - 1) -5.00 + 1] = n$$

$$-3.50 / [(.530) (-4.00)] = n$$

$$-3.50 / 2.12 = n$$

$$1.65 = n$$

Questions

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