Mastering Ophthalmic Formulae

Phernell Walker, MBA, ABOM, LDO
Renowned National Speaker

PURE OPTICS

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Optometric Strategy | Business Operations | Practice Management

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- Owner | Pure Optics LLC
- Author | Pure Optics
- American Board of Opticianry | Board of Directors
- Pacific University College of Optometry | Past Adjunct Professor
- Master in Business Administration (MBA)
- Master in Ophthalmic Optics (ABOM)
- Licensed Dispensing Optician (WA-LDO)
- National Contact Lens Examiners Certified (NCLEC)

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Cira Collins

ABOM, MPH

- 18 years industry experience
- Corporate and Private Practice
- Dispenser, Buyer and Vendor
- Currently representing Lafont in the PNW
- NAO Fellow, Member of Three State Associations
- Master of Public Health, International Health and Development – Tulane University
- Returned Peace Corps Volunteer
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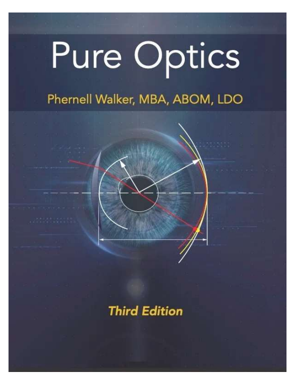

Resource

Pure Optics (2023)

Phernell Walker, MBA, ABOM, LDO

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Objectives

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

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Lens Power

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

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Using Formulae to Create Lens Appeal

Practical:

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

Exact:

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

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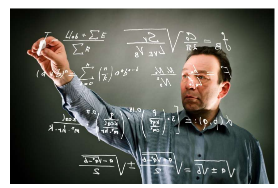
Variable Key

- D_1 = base curve
- D_2 = ocular curve
- t = thickness (M)
- n = refractive index
- D_e = total dioptric power
- 1 = constant



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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?

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

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And there you have it!

Formula:

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

$+9.00 + -2.00 + (7mm)\,(9.00)^2 / 1.60 = D_e$

$+7.00 + (\,.007m)\,(81\,) / 1.60 = D_e$

$+7.00 + .567 / 1.60 = D_e$

$+7.00 + .35 = D_e$

$+7.35 = D_e$

*Power experienced by the patient ignoring vertex distance

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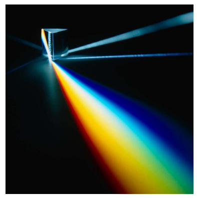
Resolving and Resulting Prism

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



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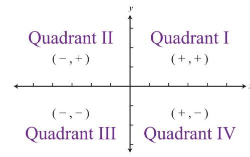
Prism Rectangular Form

- 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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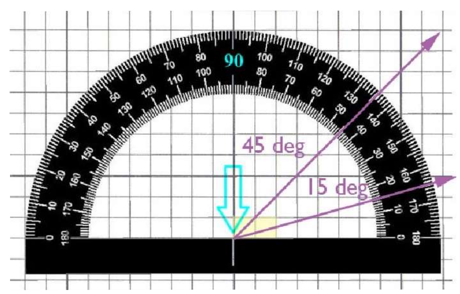
Polar to Rectangular Prism Conversion



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Polar Notation to Rectangular

$V = (D_e)(\text{sine } a)$

$H = (D_e)(\text{cosine } a)$

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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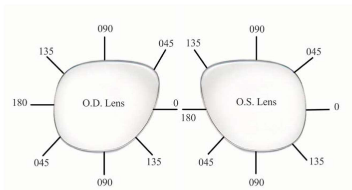
Solution:

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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Convert Resultant into Polar Prism

Example:

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 Viewed Are Skewed Through My Glasses

Rx:

OD: -8.50 DS

OS: -8.50 DS

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

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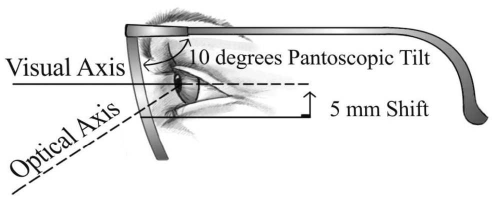
Martin's Tilt Formula



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Mastering Optics with Formulae

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

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

Variable Key:

S_{De} = effective sphere power

S = sphere power

n = refractive index

C_{De} = effective cylinder

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

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

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

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

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

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

$S_{De} = -8.68$

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

$C_{De} = -8.68\,(\tan 15)^2$

$C_{De} = -8.68\,(\tan 15)^2$

$C_{De} = (-8.68)\,(\tan 15)^2$

$C_{De} = (-8.68)\,(\tan 15)^2$

$C_{De} = (-8.68)\,(0.26759)^2$

$C_{De} = (-8.68)\,(0.7160441)$

$C_{De} = 0.716$

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Final: 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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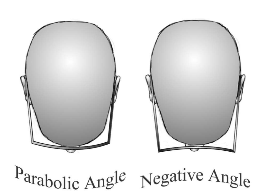
I Feel Nauseous

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 / 2_n]

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

S_{De} = -7.00 [1 + (sin20)^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} = -7.238

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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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Final: 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 Factors

- Base Curve
- Dioptric Power
- Thickness
- Vertex Distance
- Refractive index

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Magnification

Ms = 1 / (1- (t) (D_1)) / n
Mp = 1 / (1 - De (hm))
(Ms) (Mp) = Mt
(Mt -1) 100 = % of X

Ms = Shape Factor
Mp = Power Factor
Mt = Magnification Total

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Practice Makes Perfect

Example:

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. -6.50 D.S. (thickness 4mm)

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Step I: Calculate Shape Factor

OD Lens Only:

MS = 1 / 1 – (t /n) (D_1)
MS = 1 / 1 – (.005/ 1.66) (2)
MS = 1 / 1 – (.003) (2)
MS = 1 / 1 – .006
MS = 1 / .994
MS = 1.006

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Step II: Calculate Power Factor

O.D. Lens Only:

MP = 1 / 1 – (h) (D)
MP = 1 / 1 – (.013)(-8.75)
MP = 1 / 1 - .113
MP = 1 / .887
MP = 1.127

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Step III: Step x Power

OD Lens Only:

SM = [(MS) (MP) -1] 100
SM = [(1.006) (1.127) - 1] 100
SM = [1.133-1] 100

Answer:

Spectacle Magnification = 13.30%

(Minus Lenses equal 13.30% demagnification)

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Step I: Calculate Shape Power

O.S. Lens Only:

MS = 1 / 1 – (t /n) (D_1)
MS = 1 / 1 – (.004/ 1.66) (2)
MS = 1 / 1 – (.002) (2)
MS = 1 / 1 – .004
MS = 1 / .996
MS = 1.004

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Step II: Calculate Power Factor

O.S. Lens Only:

MP = 1 / 1 – (h) (D)
MP = 1 / 1 – (.013) (-6.00)
MP = 1 / 1 - .078
MP = 1 / .922
MP = 1.084

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Final Step

Multiply Shape & Power Factors

SM = [(SF) (PF) -1] 100

SM = [(1.004) (1.084) - 1] 100

SM = [1.088 - 1] 100

SM = 8.80% (minus power results in demagnification)

O.D. 13.30% demagnification

O.S. 8.80% demagnification

Difference = 4.50%.

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Manipulating Plano Lenses

How can you manipulate the image size of a plano lens?

Plano lenses are considered "afocal" (dioptric power factor is unity), which means that a change in magnification can be created using the shape factor alone.

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Manipulating Plano Lenses

$$Mt = -t\,(D2) / 10_n$$

- Mt = Total magnification needed
- -t = thickness
- D2 = ocular curve
- n = substrate's refractive index

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CC:	Blurry Vision
Location:	Distance Vision
Onset:	New Contacts
Severity:	6
Duration:	Constant
Mod. Fac:	None

Blurry Vision with New Soft Toric Contacts

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Soft Toric Contact Lenses

Presenting Rx	SCOR
- Cyl: -8.50 -2.00 x 180	- CYL: -0.50 -0.75 x 140
+Cyl: -10.50+2.00 x 090	+ Cyl: -1.25 +0.75 x 050

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Combining Cylinders

$C^2 = C_1^2 + C_2^2 + 2C_1 C_2 \cos 2y$

$S = (S_1 + S_2 + C_1 + C_2 - C) / 2$

${}^{-1}\tan /2 = C_2 \sin 2y / C1 + C2 \cos 2y$

- Lower Axis Rx= $S_1\ C_1 \times a_1$
- Higher Axis Rx $= S_2\ C_2 \times a_2$
- $y = a_2 - a_1$

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Calculate New Cylinder

$C^2 = C_1^2 + C_2^2 + 2C_1 C_2 \cos 2y$

$C^2 = 0.75^2 + 2^2 + 2\,(0.75)\,(2)\,\cos 2(40)$

$C^2 = 0.5625 + 4 + 1.50\,(2)\,\cos 80$

$C^2 = 0.5625 + 4 + 3\,(0.17)$

$C^2 = \sqrt{5.07}$

C = +2.25 *plus cylinder format

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Calculate New Sphere

$S = (S_1 + S_2) + (C_1 + C_2 – C) / 2$

S = (-10.50 + -1.25) + (0.75 + 2.00 – 2.25) / 2

S = -11.75 + -0.50/ 2

S = -11.75 + -0.25

S = -11.50 *plus cylinder format

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Calculate New Axis

$^{-1}$tan /2 = C_2 sin 2y / C_1 + C_2 COS 2y

$^{-1}$tan /2 = 2.25 sin 80 / 0.75 + 2 COS 80

$^{-1}$tan /2 = 2.21/ 1.10

$^{-1}$tan /2 = 2.01

$^{-1}$tan /2 = 64

Axis = 31.77 degrees of change

Add 32 degrees to a_1 (32 + 50 = 082)

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Corrected Soft Toric Contacts

Presenting Rx

+ CYL: -10.50 +2.00 x 090
- CYL: -8.50 -2.00 x 180

Corrected Rx

+ CYL: -11.50 +2.25 x 082
- CYL: -9.25 -2.25 x 171

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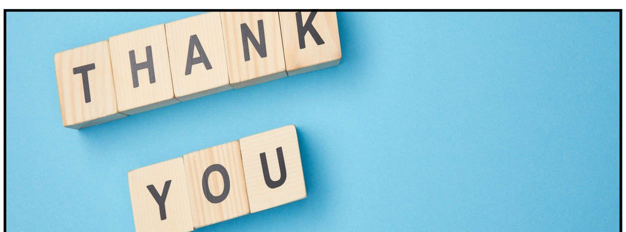

- Make sure you follow Phernell and learn if he won:

International Optician of the Year!

- Follow me too on Linked In.

Reach out at cira@cira.me

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