OPTICAL FORMULAE

For Contact and Intraocular Lenses

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1980

SAG DEPTH

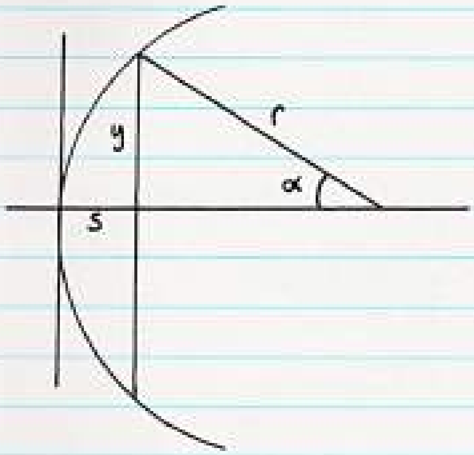
$$r_{sphere} = \frac{y^2 + s^2}{2s}$$

$$r_{conic} = \frac{y^2 + ps^2}{2s}$$

$$S_{SPH} = r - r\cos\alpha$$

$$Sag_{MULTICURVE} = \frac{R_1}{p_1} - \frac{\sqrt{R_2^2 - p_2 y_2^2}}{p_2} + \frac{\sqrt{R_2^2 - p_2 y_1^2}}{p_2} - \frac{\sqrt{R_3^2 - p_3 y_3^2}}{p_3} + \frac{\sqrt{R_3^2 - p_3 y_2^2}}{p_3} - \ldots\ldots - \frac{\sqrt{R_1 - p_1^2 y_1^2}}{p_1}$$

SAGGITAL DEPTH



r = radius
s = sag
y = ½ diameter
e = eccentricity

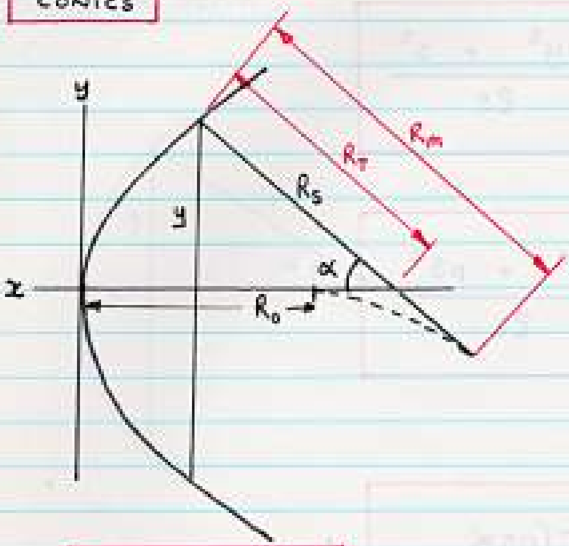
$$p = 1 - e^2$$

$$Sag_{sphere} = r - \sqrt{r^2 - y^2}$$

$$Sag_{conic} = \frac{r_0 - \sqrt{r_0^2 - p y^2}}{p}$$

$$Sag_{1.0} = \frac{y^2}{2 r_0}$$

CONICS



e = eccentricity
R_o = apical radius
R_S = saggital radius
R_T = tangential radius
R_m = meridianal radius
y = $\frac{1}{2}$ diameter
n = refractive index
f = focal length

$$R_o = f(1+e)$$

$$p = 1 - e^2$$

$$px^2 - 2R_o x + y^2 = 0$$

$$R_S^2 = R_o^2 + e^2 y^2$$

$$R_T = \sqrt{R_o^2 + e^2 y^2}$$

$$e = \frac{\sqrt{1 - \frac{R_T}{R_m}}}{\sin \alpha}$$

$$R_m = \frac{R_T^3}{R_o^2}$$

$$R_T = \frac{R_o}{\sqrt{1 - e^2 \sin^2 \alpha}}$$

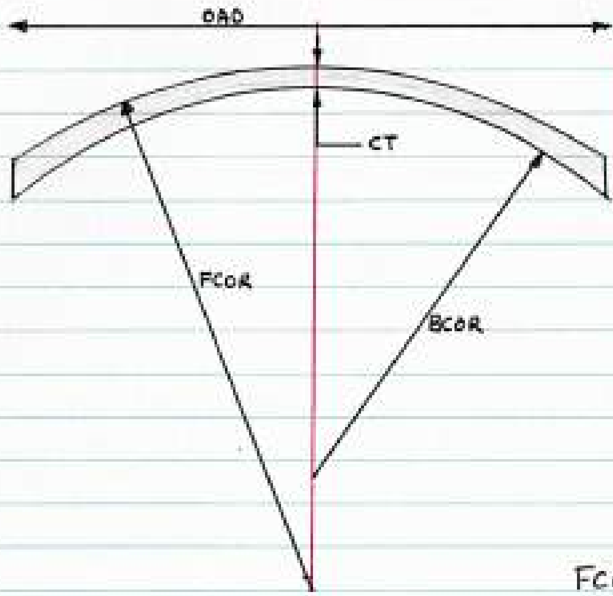
CONIC ABBERATIONS

$$\text{Astigmatic Abberation} = \frac{1000(n-1)}{R_S} - \frac{1000(n-1)}{R_T}$$

$$\text{Spherical Abberation} = \frac{1000(n-1)}{R_S} - \frac{1000(n-1)}{R_o}$$

Nb: For lens in situ replace $1000(n-1)$ with $1000(n-n')$
where n is ref. ind. of lens and $n' = 1.333$

CURVITURE + POWER



$$BVP = \frac{F_1 + F_2 - (t/n) F_1 F_2}{1 - (t/n) F_1}$$

D = Surface Power
F_1 = Surface Power F.S.
F_2 = Surface Power B.S
n = refractive index
r = radius
FCOR = Front Central Optic Rad.
BCOR = Back Central Optic Rad.
t, CT = Centre Thickness
BVP = Back Vertex Power
FVP = Front Vertex Power

$$F_1 = \frac{1000(n-1)}{FCOR}$$

$$F_2 = \frac{1000(n-1)}{BCOR}$$

$$D = \frac{(n-1)1000}{r}$$

$$F_1 = \frac{1000\,n\,(BVP + F_2)}{(1000\,n + CT.F_2 + CT.BVP)}$$

$$BVP = \frac{F_1}{1 - \left[\frac{F_1 \cdot CT}{1000\,n}\right]} - F_2$$

1a. BACK VERTEX

$$FCOR = \frac{(n-1)(1000.n.BCOR + CT.BVP.BCOR + CT.1000(n-1))}{n.(BVP.BCOR + 1000(n-1))}$$

1b. BACK VERTEX

$$BVP = \frac{1000(n-1)(n.BCOR - n.FCOR + (n-1).CT)}{BCOR.(n.FCOR - (n-1).CT)}$$

2a. FRONT VERTEX

$$FCOR = \frac{1000(n-1).(n.BCOR + CT(n-1))}{(1000.n.(n-1) + n.FVP.BCOR + FVP.CT.(n-1))}$$

2b. FRONT VERTEX

$$FVP = \frac{1000.(n-1).(n.BCOR - n.FCOR + CT(n-1))}{FCOR.(n.BCOR + CT(n-1))}$$

$$FVP = \frac{BVP}{1 - \left[\frac{CT.BVP}{1000.n}\right]}$$

FLANGE RADII

FCOD = Front Central Optic Diameter
OAD = Overall Diameter
CT = Centre Thickness
FCOR = Front Central Optic Radius
BCOR = Back Central Optic Radius
ET = Edge Thickness
FCR_1 = Flange Radius.

1. Coordinate Method.

$$x_1 = \frac{FCOD}{2}$$

$$x_2 = \frac{OAD}{2}$$

$$y_1 = CT + \left(Sag^{OAD}_{BCOR}\right) - \left(Sag^{FCOD}_{FCOR}\right)$$

$$y_2 = ET$$

$$V = \frac{x_2^2 - x_1^2 + y_2^2 - y_1^2}{2(y_2 - y_1)}$$

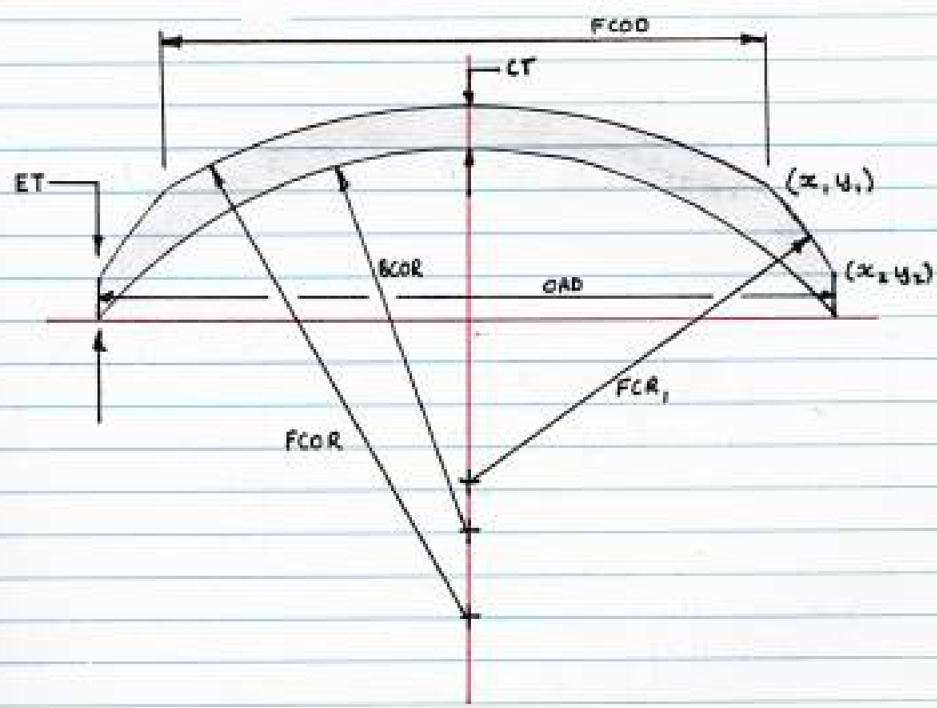
$$FCR_1 = \sqrt{x_2^2 + (y_2 - V)^2}$$

N.B. Sag^{OAD}_{BCOR} = Total Sag of B.S.

2. Algebraic Method

$$\beta = Sag_{BCOR}^{OAD} + CT - ET - Sag_{FCOR}^{FCOD}$$

$$FCR_1 = \sqrt{\left[\frac{\left(\frac{1}{2}OAD\right)^2 - \left(\frac{1}{2}FCOD\right)^2 - \beta^2}{2\beta}\right]^2 + \left(\frac{1}{2}OAD\right)^2}$$



PRISM OFFSET

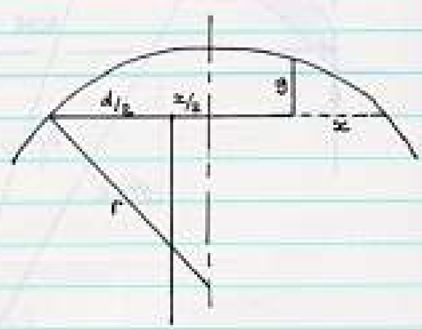
$$g = \frac{dp}{200(n-1)}$$

$$o.s. = \frac{d.g.}{2.\, Sag^{d}_{r}}$$

g = thickness difference
d = diameter
r = radius
p = prism
o.s. = offset
n = refractive index
x = Total offset Throw
x/2 = Distance between centres

$$g = \frac{1}{2}\left(\sqrt{4r^2 + 2dx - x^2 - d^2} - \sqrt{4r^2 - d^2 - 2dx - x^2}\right)$$

$$x = g\sqrt{\frac{4r^2 - d^2 - g^2}{d^2 + g^2}}$$



$$g = \frac{dp}{100(n-1) + \left[\frac{np^2}{200}\right]}$$

VERTEX

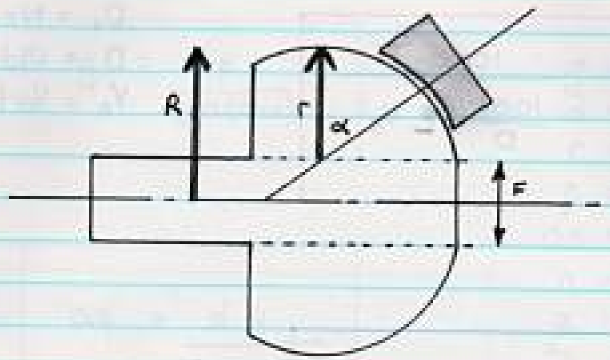
$$D_v = \frac{1000}{\frac{1000}{D} - V_D}$$

D_v = New Power
D = Old Power
V_D = Vertex Distance

$$R_c = \frac{R_s}{1 - v R_s}$$

R_c = Power at Cornea
R_s = Power at Vertex
v = Vertex Dist.

CON-O-COID® TOOLS AND LAPS



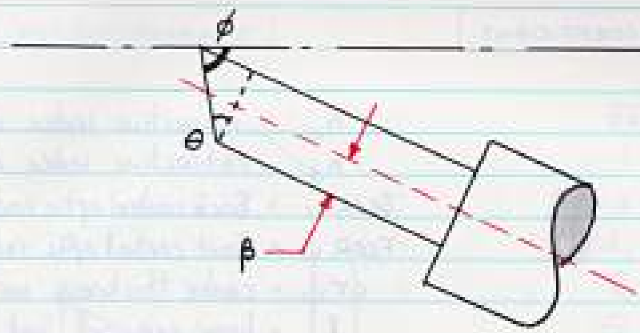
F = Diameter of flat
r = tool radius
R = ½ diameter of tool

$$\text{Transversity} = R - r$$

$$F = 2(R - r)$$

$$\text{Radius at apex} = r + \frac{(R - r)}{\cos \alpha}$$

Transversities: Ecc 0.9 = 1.0 mm
Ecc 1.0 = 1.2 mm
Ecc 1.1 = 1.4 mm



β = ½ diameter of tool
ϕ = tool incidence angle
θ = tool face angle
e = true generated ecc

$$\text{Tool Radius} = \beta \cos\theta$$

$$\text{Radius Cut} = \frac{\beta \cos\theta}{\cos\phi}$$

$$\text{Tool Eccentricity} = \sin\theta$$

$$\text{Ecc. Generated} = \frac{\sin\theta}{\cos\phi}$$

$$e = \sqrt{\frac{\beta^2 - \left[\frac{\beta \cos\phi}{\cos\theta}\right]^2}{\beta^2}}$$

Notes:

$\theta = 35^\circ$

$\phi = 55^\circ.00'$ for Ecc 1.0
$\phi = 58^\circ.35'$ for Ecc 1.1
$\phi = 50^\circ.24'$ for Ecc 0.9
$\phi = 34^\circ.58'$ for Ecc 0.7

$\beta_{0.7}$ = Radius Cut

$\beta_{0.9} = \frac{\text{Radius Cut}}{1.285}$

$\beta_{1.0} = \frac{\text{Radius Cut}}{1.482}$

$\beta_{1.1} = \frac{\text{Radius Cut}}{1.571}$

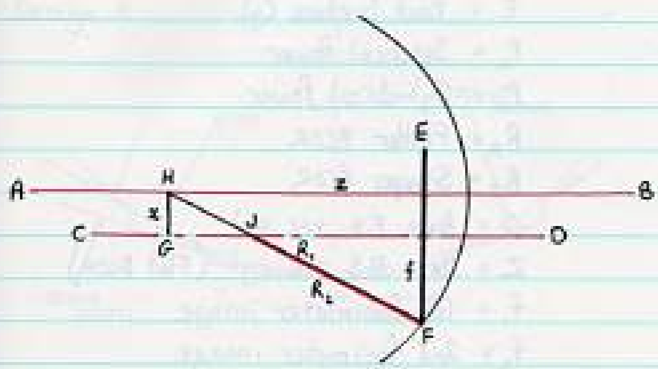
POWER EXPANSION COEFFICIENT

n_w = refractive index wet
n_d = refractive index dry
$BCOR_w$ = Back central optic radius wet
$FCOR_w$ = Front central optic radius dry
CT_w = centre thickness wet
ℓ = linear exp coeff wet to dry
PEx = pow exp coeff wet to dry

$$PEX = \frac{\ell^3 . (n_d - 1) . (n_d . BCOR_w - n_d . FCOR_w + (n_d - 1) CT_w) . (n_d FCOR_w - (n_d - 1) . CT_w)}{(n_w - 1) . (n_w . BCOR_w - n_w . FCOR_w + (n_w - 1) CT_w) . (n_w FCOR_w - (n_w - 1) . CT_w)}$$

Method:
1. Calculate $FCOR_w$ from wet parameters
2. Calculate $FCOR_d$ from $FCOR_w$ and ℓ
3. Calculate BVP_d from dry parameters
4. Calculate PEx from BVP_d and BVP_w

TORIC FLY-CUT FORMULAE



$\overline{EF}$ = Diameter of flycut locus
f = Radius of flycut locus
x = Z axis offset
R_1 = Spherical Radius Cut
R_2 = Cylindrical Radius Cut
$\overline{CD}$ = Axis of tool rotation.
$\overline{AB}$ = Axial Axis of workpiece

Conditions for cut:

$R_1 > f < R_2$

$R_1 < Z > R_2$

$$x = \frac{f(R_1 - R_2)}{R_2}$$

$$z = \sqrt{R_1^2 - (f + x)^2}$$

BITORIC POWERS

- E = Back Surface Cyl.
- P_L = Spherical Power
- P_c = Cylindrical Power
- R_A = Flatter BCOR
- R_B = Steeper BCOR
- Q = Axis F.S. +ve cyl
- Z = Axis B.S -ve cyl (Flat BCOR)
- f_1 = 1st focimeter image
- f_2 = 2nd focimeter image
- n = refractive index

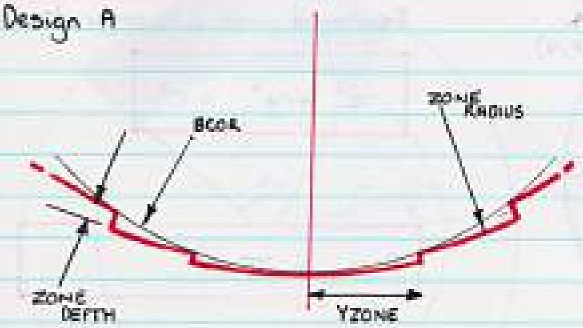
$$E = \frac{(R_A - R_B).1000.(n-1)}{R_A.R_B}$$

$$f_1 = \sqrt{\frac{((((-2\cos(-2(Q-Z))P_c)+E)E)+P_c^2)}{2}} + \frac{(P_c + 2P_L - E)}{2}$$

$$f_2 = \frac{(P_c + 2P_L - E)}{2} - \sqrt{\frac{((((-2\cos(-2(Q-Z))P_c)+E)E)+P_c^2)}{2}}$$

HOLOGRAPHIC BIFOCAL

Design A



Constants:

(2µ Design →)
DEPTH = 0.000002

(3µ Design →)
DEPTH = 0.000003

WV555 = 0.000000555 (Design Wavelength)

BCOR = Back Central Optic Rad.

Y_{ZONE} = ½ DIA OF ZONE

ADD = Add Power

R_{ZONE} = Radius of ZONE

ADD	2.0	2.5	3.0
NO OF ZONES	7	8	9

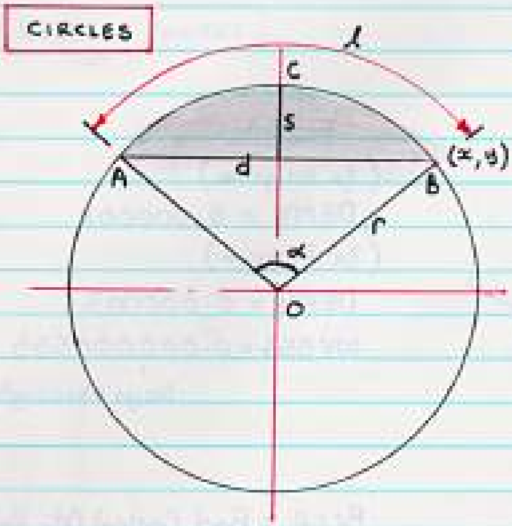
$$Y^2_{ZONE} = \frac{2 . WV555 . ZONE\ NUMBER}{ADD}$$

$$Sag_{ZONE} = BCOR - \sqrt{BCOR^2 - Y^2_{ZONE}}$$

$$K = Sag_{ZONE} - Sag_{PREVIOUS\ ZONE} - DEPTH$$

$$R_{ZONE} = \sqrt{\left(\frac{K^2 + Y^2_{ZONE} - Y^2_{PREVIOUS\ ZONE}}{2.K}\right)^2 + Y^2_{PREVIOUS\ ZONE}}$$

CIRCLES



Equation of circle with origin at 0,0 :

$$x^2 + y^2 = r^2$$

$$\text{Area} = \pi r^2$$

$$\text{CIRCUMFERENCE} = 2\pi r$$

$$d = 2\sqrt{s(2r - s)}$$

$$l = \frac{r \cdot \pi \cdot \alpha}{180}$$

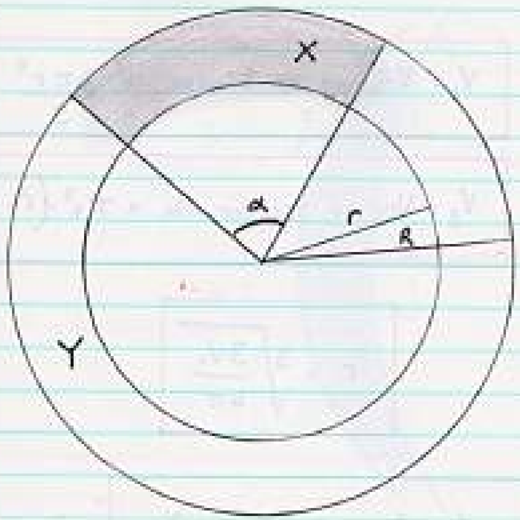
$$r = \frac{4s^2 + d^2}{8s}$$

$$\text{Area Sector AOB} = \frac{1}{2} r l$$

$$\text{Area Cap ACB} = \frac{1}{2}\left(r l - d(r - s)\right)$$

$$s = r\left(1 - \cos(\alpha/2)\right)$$

s = Sag
r = radius
d = chord diameter
α = angle of arc
l = length of arc



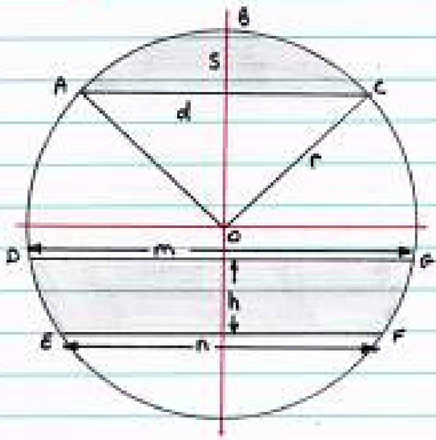
Area of ring Y $= \pi(R^2 - r^2)$

Area of X $= \frac{\alpha\pi}{360}(R^2 - r^2)$

Equation of circle with origin at g, f

$$(x-g)^2 + (y-f)^2 = k^2$$

SPHERES



$$V_1 = \text{Volume of Sphere} = \frac{4\pi r^3}{3}$$

$$V_2 = \text{Vol of Segment ABC} = \pi s^2 \left(r - \frac{s}{3}\right)$$

$$r = \sqrt[3]{\frac{3V_1}{4\pi}}$$

$$V_3 = \text{Vol of Segment DEFG} = \frac{\pi}{6} \cdot h \left(\frac{3n^2}{4} + \frac{3m^2}{4} + h^2 \right)$$

$$r = \frac{d^2 + 4s^2}{8s}$$

$$A_1 = \text{Area of Sphere} = 4\pi r^2$$

$$A_2 = \text{Area of cap ABC} = 2\pi . r . s.$$

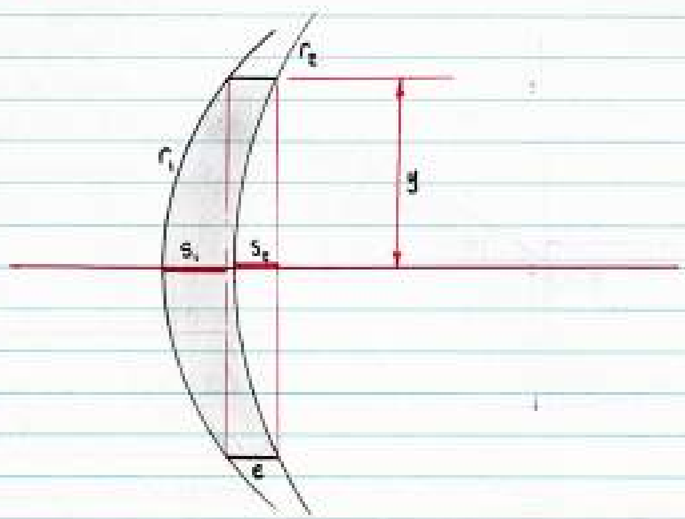
$$r = \sqrt{\frac{m^2}{4} + \left(\frac{m^2 - n^2 - 4h^2}{8h}\right)^2}$$

$$A_3 = \text{Area of DEFG} = 2\pi r h$$

$$V_2 = \frac{\pi}{3}\left(2r^3 - 2r^2\sqrt{r^2 - y^2} - y^2\sqrt{r^2 - y^2}\right)$$

r = radius of sphere
V = Volumes
A = Areas
S = Sag of cap
h = Thickness of segment
m, n, d = chord diameters

MENISCUS

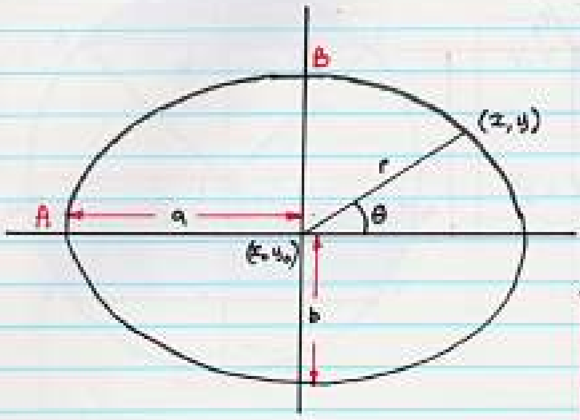


$$V = \pi y^2 e + \frac{1}{3}\pi\left(\left(2r_1^3 - (2r_1^2 + y^2)\sqrt{r_1^2 - y^2}\right) - \left(2r_2^3 - (2r_2^2 + y^2)\sqrt{r_2^2 - y^2}\right)\right)$$

$$V = \pi y^2 e + \frac{1}{3}\pi\left(3r_1 s_1^2 - 3r_2 S_2^2 - S_1^3 + S_2^3\right)$$

V = Volume of meniscus
r_1 = radius 1
r_2 = radius 2
s_1 = Sag of r_1 at 2y
S_2 = Sag of r_2 at 2y
y = $\frac{1}{2}$ Diameter
e = edge thickness

ELLIPSES



r = radius at pt (x,y)
a = ½ major axis
b = ½ minor axis
(x_0, y_0) = origin of ellipse
(x, y) = Pt on ellipse
e = eccentricity

origin at (x_0, y_0):

$$\frac{(x - x_0)^2}{a^2} + \frac{(y - y_0)^2}{b^2} = 1$$

origin at (0,0):

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = 1$$

ecc < 1.0

$$b^2 = a^2(1 - e^2)$$

$$\text{Radius of Curvature at A} = a(1 - e^2)$$

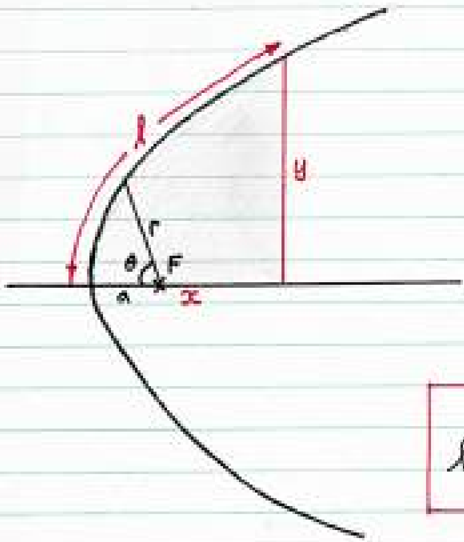
$$\text{Radius of Curvature at B} = \frac{a}{\sqrt{1 - e^2}}$$

$$\text{Area} = \pi . a . b.$$

$$r^2 = \frac{a^2 b^2}{a^2 \sin^2\theta + b^2 \cos^2\theta}$$

PARABOLAE

$$e = 1.0$$



$$(y - y_0)^2 = 4a(x - x_0)^2$$

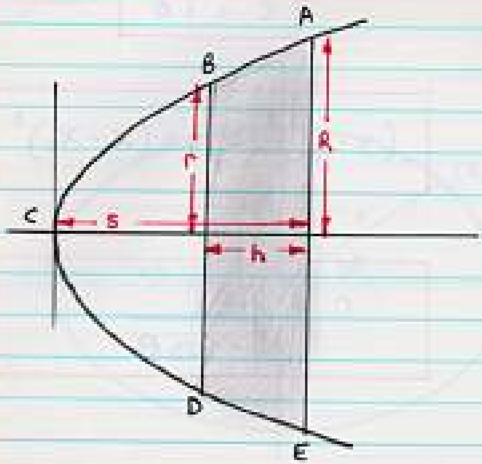
$$r = \frac{2a}{1 - \cos\theta}$$

$$l = \frac{a}{2}\left(\sqrt{\frac{2x}{a}\left(1 + \frac{2x}{a}\right)} + \text{Hyp.log}\left(\sqrt{\frac{2x}{a}} + \sqrt{1 + \frac{2x}{a}}\right)\right)$$

$$\text{Area} = {}^2/_3\, x \cdot y.$$

- a = dist from Focus to apex
- r = radius at point from focus
- l = arc length
- (x_0, y_0) = Origin
- e = eccentricity

PARABOLOID



R = large radius of rotation
r = Small radius of rotation
S = Sag of paraboloid
h = Thickness of segment

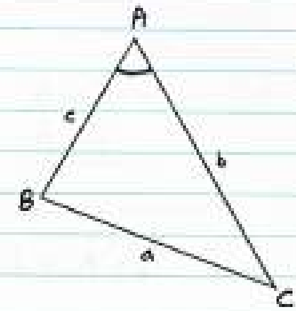
$$\text{VOLUME } \overline{ABCDE} = \frac{1}{2} \cdot \pi \cdot R^2 \cdot S$$

$$\text{VOLUME } \overline{ABDE} = \frac{\pi}{2} \cdot h \left(R^2 + r^2 \right)$$

$$\text{AREA } \overline{ABCDE} = \frac{2\pi}{3p} \left(\sqrt{\left(\frac{(2R)^2}{4} + p^2 \right)^3} - p^3 \right)$$

$$p = \frac{(2R)^2}{8S}$$

TRIGONOMETRIC IDENTITIES - Part 1.



$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C}$$

$$a^2 = b^2 + c^2 - 2bc \cos A$$

$$\sin A = \frac{2\sqrt{p(p-a)(p-b)(p-c)}}{bc}$$

$$p = \frac{a+b+c}{2}$$

$$\sin \frac{A}{2} = \sqrt{\frac{(p-b)(p-c)}{bc}}$$

$$\cos \frac{A}{2} = \sqrt{\frac{p(p-a)}{bc}}$$

$$\tan \frac{A}{2} = \sqrt{\frac{(p-b)(p-c)}{p(p-a)}}$$

$$\text{Area} = \sqrt{p(p-a)(p-b)(p-c)}$$

$$\text{Area} = \tfrac{1}{2} cb \cos A$$

$p = \frac{1}{2}$ perimeter
a, b, c = Sides of any triangle
A, B, C = Angles opposite sides

$$\text{Area} = \frac{c^2 \sin A \sin B}{2 \sin C}$$

TRIGONOMETRIC IDENTITIES - Part 2.

$$\tan A = \frac{\sin A}{\cos A}$$

$$\sin^2 A + \cos^2 A = 1$$

$$\sin 2A = 2 \sin A \cos A$$

$$\tan 2A = \frac{2 \tan A}{1 - \tan^2 A}$$

$$\cos 2A = \cos^2 A - \sin^2 A$$

$$\sin^{-1} A = \tan^{-1}\left[\frac{A}{\sqrt{1 - A^2}}\right]$$

$$\cos^{-1} A = \tan^{-1}\left[\frac{\sqrt{1 - A^2}}{A}\right]$$

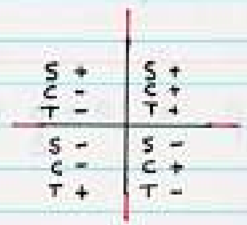
If $A + B + C = 180$

$$\tan A + \tan B + \tan C = \tan A . \tan B . \tan C$$

$$\sin(-A) = -\sin A$$

$$\cos(-A) = \cos A$$

$$\tan(-A) = -\tan A$$

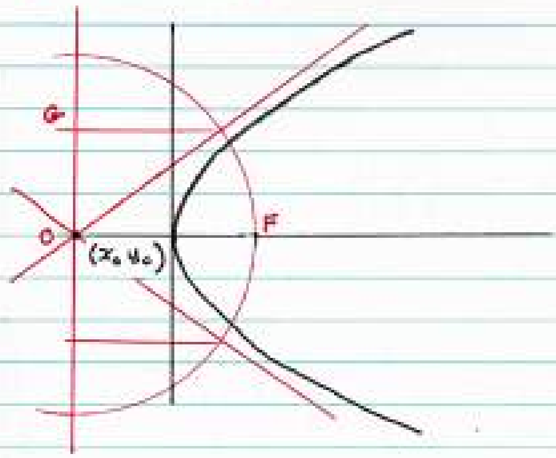


$$\sin(180 - A) = \sin A$$
$$\sin(360 - A) = -\sin A$$
$$\sin(90 - A) = \cos A$$

$$\cos(180 - A) = -\cos A$$
$$\cos(360 - A) = \cos A$$
$$\cos(90 - A) = \sin A$$

$$\tan(180 - A) = -\tan A$$
$$\tan(360 - A) = -\tan A$$
$$\tan(90 - A) = \cot A$$

HYPERBOLAE



$$a = \overline{OF}$$

$$b = \overline{OG}$$

$$e = \frac{\sqrt{a^2 + b^2}}{a}$$

$$\frac{(x-x_0)^2}{a^2} - \frac{(y-y_0)^2}{b^2} = 1$$

B+L LENS FORMULAE

$$BVP = 1000(n-1)\left[\frac{1}{FCOR - CT\left(\frac{n-1}{n}\right)} - \frac{1}{BCOR}\right]$$

$$BVP_d = 1000.\ell.(n_d-1)\left[\frac{1}{\left(\frac{(n_w-1)\,BCOR_w}{P_w.BCOR_w+n_w-1}\right)+\ell.CT_d\frac{(n_w-n_d)}{n_w n_d}} - \frac{1}{BCOR_w}\right]$$

$$BVP_d = 1000(n_d-1)\left[\frac{1}{\frac{(n_w-1)\,BCOR_d}{\ell.\ P_w.BCOR_d+n_w-1}+CT_d\frac{(n_w-n_d)}{n_w n_d}} - \frac{1}{BCOR_d}\right]$$

$$P_w = 1000.\ BVP_w$$

BVP = Back Vertex Power
n = refractive index
CT = centre thickness
ℓ = Expansion Coefficient (dry to wet)
BCOR = Back central Optic Radius
FCOR = Front Central Optic Radius
PEx = Power Exp. Coeff (dry to wet)
w, d = wet or dry

$$FCOR_d = \frac{(n_w - 1)\, BCOR_w}{\ell .\, 1000 .\, BVP_w\, BCOR_w + \ell\,(n_w - 1)} + CT_d\, \frac{(n_w - 1)}{n_w}$$

$$FCOR_d = \frac{(n_w - 1)\, BCOR_d}{\ell .\, 1000 .\, BVP_w .\, BCOR_d + (n_w - 1)} + CT_d\, \frac{(n_w - 1)}{n_w}$$

$$PEX = \frac{1000 .\, BVP_w}{\ell\, 1000\,(n_d - 1)\left[\dfrac{1}{\dfrac{(n_w - 1)\, BCOR_w}{(P_w BCOR_w + n_w - 1)} + \ell\, CT_d\, \dfrac{(n_w - n_d)}{n_w n_d}} - \dfrac{1}{BCOR_w}\right]}$$

LINEAR EQUATIONS

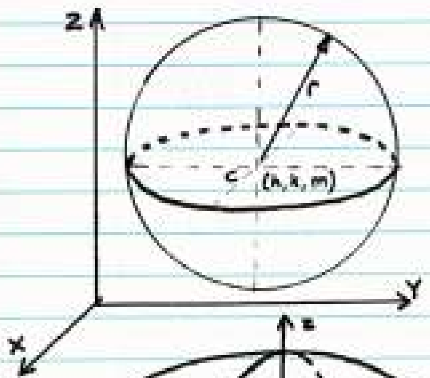
$$Ax^2 + Bx + C = \emptyset$$

$$x_{1,2.} = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

$$x_1 + x_2 = -\frac{B}{A}$$

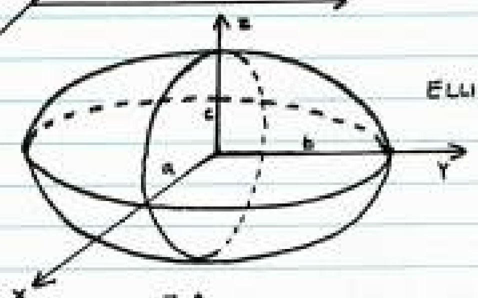
$$x_1 . x_2 = \frac{C}{A}$$

SPACIAL SURFACES



SPHERE

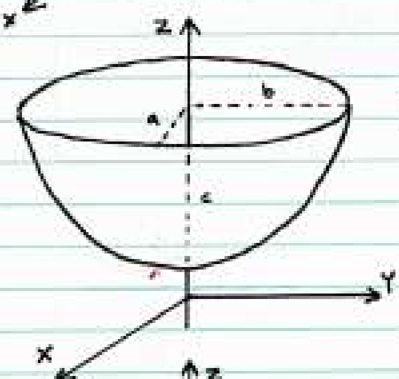
$$(x-h)^2 + (y-k)^2 + (z-m)^2 = r^2$$



ELLIPSOID

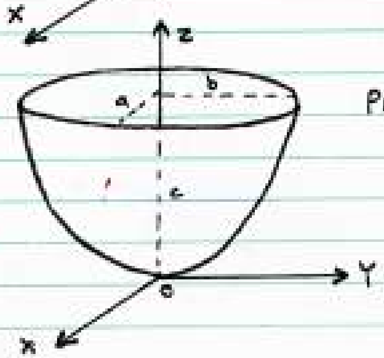
$$\frac{x^2}{a^2} + \frac{y^2}{b^2} + \frac{z^2}{c^2} = 1$$

$$\frac{(x-h)^2}{a^2} + \frac{(y-k)^2}{b^2} + \frac{(z-m)^2}{c^2} = 1$$



HYPERBOLOID

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} - \frac{z^2}{c^2} = -1$$



PARABOLOID

$$\frac{x^2}{a^2} + \frac{y^2}{b^2} = \frac{z}{c}$$

PRISMATIC EFFECTS

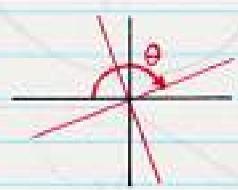
$$H = 0.10\left(F_s . x + F_c \operatorname{Sin}\theta \left(x \operatorname{Sin}\theta + y \operatorname{Cos}\theta\right)\right)$$

$$V = 0.10.\left(F_s y + F_c \operatorname{Cos}\theta \left(x \operatorname{Sin}\theta + y \operatorname{Cos}\theta\right)\right)$$

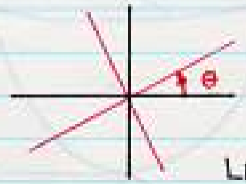
$$x = \frac{H F_s + H F_c \operatorname{Cos}^2\theta - V F_c \operatorname{Sin}\theta . \operatorname{Cos}\theta}{0.10\left(F_s\left(F_s + F_c\right)\right)}$$

$$y = \frac{V F_s + V F_c \operatorname{Sin}^2\theta - H F_c \operatorname{Sin}\theta \operatorname{Cos}\theta}{0.10\left(F_s\left(F_s + F_c\right)\right)}$$

F_s = Sph Power
F_c = Cyl Power
θ = Cyl Axis
x = Horizontal displacement from centre (mm)
(+ve inwards)
y = Vertical displacement from centre (mm)
(+ve upwards)
H = Horizontal Prism Effect
(+ve base out)
V = Vertical Prism Effect
(+ve base down)

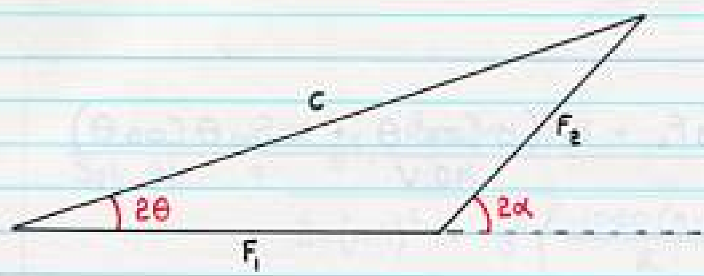


RIGHT



LEFT

CROSSED CYLINDERS



$$\tan 2\theta = \frac{F_2 \sin 2\alpha}{F_1 + F_2 \cos 2\alpha}$$

$$C = \sqrt{F_1^2 + F_2^2 + 2F_1F_2 \cos 2\alpha}$$

$$C = F_2 \frac{\sin 2\alpha}{\sin 2\theta}$$

$$\tan\theta = \frac{S + C - F_1}{S + C} \cdot \tan\alpha$$

$$S = \frac{1}{2}(F_1 + F_2 - C)$$

$$S = F_1 \sin^2\theta + F_2 \sin^2(\alpha - \theta)$$

F_1, F_2 = Cyl Powers (Same Sign)
α = Acute angle between F_1 and F_2
C = Resultant Cyl Power
S = Resultant Sph Power
θ = Angle between C and F_1

TRANSVERSE CHROMATISM

$$T.Ch.Ab_V = \frac{yF_s + F_c\left(y\cos^2\theta + x\sin\theta\cos\theta\right)}{10.V}$$

$$T.Ch.Ab_H = \frac{xF_s + F_c\left(y\sin\theta\cos\theta + x\sin^2\theta\right)}{10.V}$$

$T.Ch.Ab_V$ = Transverse Chromatism Vertical Abberation
$T.Ch.Ab_H$ = Transverse Chromatism Horizontal Abberation
x = Horizontal Displacement (mm)
y = Vertical Displacement (mm)
F_s : Spherical Power
F_c : Cylindrical Power
θ = Axis of cyl.
V = Vertical Prism.

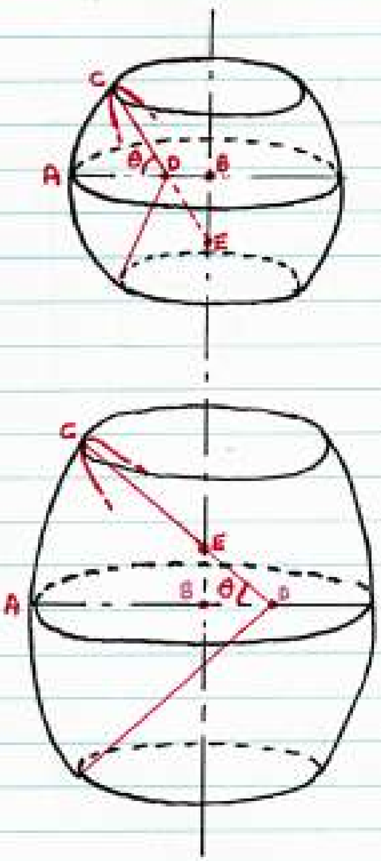
(F_s, F_c, θ: All same Sign for axis.)

SPHERICAL ABBERATION

$$\text{Sph. Ab.} = \frac{y^2 \cdot \dfrac{1000(n-1)}{R}}{2n(n-1)^2 + y^2\left(\dfrac{1000(n-1)}{R}\right)^2}$$

Sph. Ab. = Spherical Abberation
2y = Diameter of zone
n = Refractive index
R = Radius of surface

TOROIDAL RADII



$R_{Equatorial} = \overline{AB} = R_E$

$R_{Transverse} = \overline{AD} = R_T$

$R_{saggital} = R_T + (R_E - R_T)\cos\theta$

$= \overline{CE}$

TRIGONOMETRIC IDENTITIES - PART 3

$$\sin^2 A = \frac{1}{2}(1 - \cos 2A)$$

$$\cos^2 A = \frac{1}{2}(1 + \cos 2A)$$

$$\sin^3 A = \frac{1}{4}(3\sin A - \sin 3A)$$

$$\cos^3 A = \frac{1}{4}(3\cos A + \cos 3A)$$

$$t = \tan \tfrac{1}{2}A$$

$$\cos A = \frac{1 - t^2}{1 + t^2}$$

$$\sin A = \frac{2t}{1 + t^2}$$

$$\sin A + \sin B = 2\sin\left(\frac{A+B}{2}\right).\cos\left(\frac{A-B}{2}\right)$$

$$\sin A - \sin B = 2\cos\left(\frac{A+B}{2}\right).\sin\left(\frac{A-B}{2}\right)$$

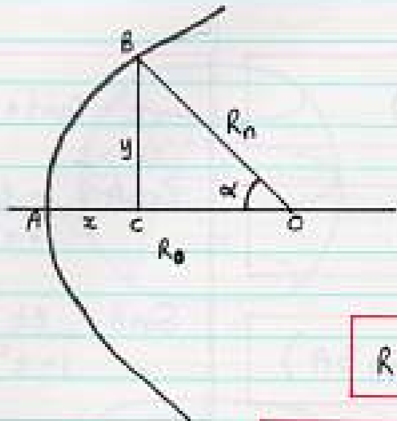
$$\cos A + \cos B = 2\cos\left(\frac{A+B}{2}\right)\cos\left(\frac{A-B}{2}\right)$$

$$\cos A - \cos B = -2\sin\left(\frac{A+B}{2}\right)\sin\left(\frac{A-B}{2}\right)$$

$$\tan A + \tan B = \frac{\sin(A+B)}{\cos A.\cos B}$$

$$\tan A - \tan B = \frac{\sin(A-B)}{\cos A.\cos B}$$

CONIC ON FIXED CENTRE - PART 1



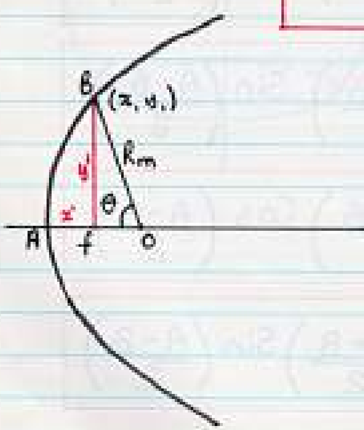
$\overline{AO} = R_o$ = Apical Radius
$\overline{BO} = R_n$ = Radius at Point
$\overline{BC} = y$
$\overline{AC} = x$
e = eccentricity
f = focus
R_m = Radius from focus

$$R_n^2 = R_o^2 + e^2 x^2$$

$$p = 1 - e^2$$

$$R_n^2 = R_o^2 + e^2 \left[\frac{R_o - \sqrt{R_o^2 - p y^2}}{p} \right]^2$$

$$R_o = \frac{R_n}{1+e^2} \left(e^2 \cos\alpha - \sqrt{e^2 \sin^2\alpha + 1} \right)$$



$$R_m = \frac{f(1+e)}{1 + e\cos\theta}$$

$$R_o = f(1+e)$$

$$y_1^2 = e f (1+e) x_1 - (1-e^2) x_1^2$$

CONIC ON FIXED CENTRE – PART 2

$$\cos\alpha = \frac{R_o e - \sqrt{(R_n^2 - R_o^2)}}{R_n e}$$

$$R_n = \frac{R_o\left(e^2\cos\alpha - \sqrt{1 + e^2\sin^2\alpha}\right)}{\left(e^2\cos^2\alpha - 1\right)}$$

$$R_o = \frac{e^2\sqrt{R_n^2 - y^2} - R_n\sqrt{e^2y^2 + R_n^2}}{R_n(1+e^2)}$$

TRIGONOMETRIC FORMULAE - PART 4

$$\operatorname{Sin}(A+B) = \operatorname{Sin}A \operatorname{Cos}B + \operatorname{Cos}A \operatorname{Sin}B$$

$$\operatorname{Sin}(A-B) = \operatorname{Sin}A \operatorname{Cos}B - \operatorname{Cos}A \operatorname{Sin}B$$

$$\operatorname{Cos}(A+B) = \operatorname{Cos}A \operatorname{Cos}B - \operatorname{Sin}A \operatorname{Sin}B$$

$$\operatorname{Cos}(A-B) = \operatorname{Cos}A \operatorname{Cos}B + \operatorname{Sin}A \operatorname{Sin}B$$

$$\operatorname{Tan}(A+B) = \frac{\operatorname{Tan}A + \operatorname{Tan}B}{1 - \operatorname{Tan}A \operatorname{Tan}B}$$

$$\operatorname{Tan}(A-B) = \frac{\operatorname{Tan}A - \operatorname{Tan}B}{1 + \operatorname{Tan}A \operatorname{Tan}B}$$

$$\operatorname{Tan}A \operatorname{Tan}B = \frac{\operatorname{Tan}A + \operatorname{Tan}B}{\operatorname{Cot}A + \operatorname{Cot}B}$$

$$\operatorname{Sin}A \operatorname{Cos}B = \frac{1}{2}\left[\operatorname{Sin}(A+B) + \operatorname{Sin}(A-B)\right]$$

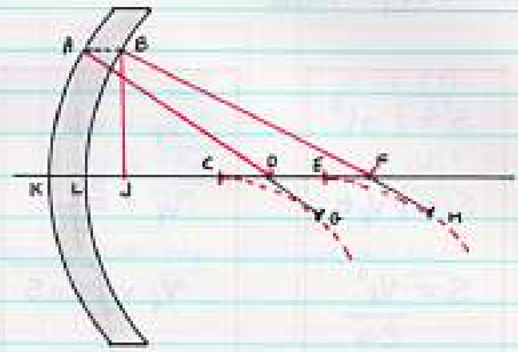
$$\operatorname{Cos}A \operatorname{Cos}B = \frac{1}{2}\left[\operatorname{Cos}(A+B) + \operatorname{Cos}(A-B)\right]$$

$$\operatorname{Sin}A \operatorname{Sin}B = \frac{1}{2}\left[\operatorname{Cos}(A-B) - \operatorname{Cos}(A+B)\right]$$

LENS ABERRATIONS

$$R_S^2 = R_o^2 + e^2 y^2$$

$$R_T = \frac{R_S^3}{R_o^2}$$



$$L.Sph.Ab = 1000\left[\frac{R_S^B n(n-1) + R_S^F n(nm-n) - ct(n-1)(nm-n)}{R_S^B R_S^F n} - \frac{nBCOR(n-1) + nFCOR(nm-n) - xt(n-1)(n-nm)}{n.FCOR.BCOR}\right]$$

$$L.Ast.Ab = 1000\left[\frac{R_S^B n(n-1) + R_S^F n(nm-n) - xt(n-1)(nm-n)}{R_S^B R_S^F n} - \frac{nR_T^B n(n-1) + R_T^F n(nm-n) - xt(n-1)(nm-n)}{R_T^B R_T^F . n}\right]$$

R_S^B = Sagital Radius Back Surface ($\overline{BF}$)

R_S^F = Sagital Radius Front Surface ($\overline{AD}$)

R_T^B = Tangential Radius Back Surface ($\overline{BH}$)

R_T^F = Tangential Radius Front Surface ($\overline{AG}$)

L.Sph.Ab = Lens Spherical Aberration

L.Ast.Ab = Lens Astigmatic Aberration

n = refractive index material

nm = refractive index medium (1.333)

FCOR = Front Central Optic Radius ($\overline{KC}$)

BCOR = Back Central Optic Radius ($\overline{LE}$)

y = $\frac{1}{2}$ Diameter to measure Aberration ($\overline{JB}$)

CT = Centre Thickness ($\overline{KL}$)

xt = Thickness at y ($\overline{AB}$)

e = eccentricity

MECHANICS - linear

$$S = \frac{1}{2} a t^2$$

$$S = \frac{1}{2} V_f t$$

$$S = \frac{V_f^2}{2a}$$

$$V_f = at$$

$$V_f = \frac{2S}{t}$$

$$V_f = \sqrt{2aS}$$

$$t = \frac{2S}{V_f}$$

$$t = \sqrt{\frac{2S}{a}}$$

$$t = \frac{V_f}{a}$$

$$a = \frac{2S}{t^2}$$

$$a = \frac{V_f^2}{2S}$$

$$a = \frac{V_f}{t}$$

$$S = V_o t + \frac{1}{2} a t^2$$

$$S = \frac{(V_f + V_o)t}{2}$$

$$S = \frac{(V_f^2 - V_o^2)}{2a}$$

$$S = V_f t - \frac{1}{2} a t^2$$

$$V_f = V_o + at$$

$$V_f = \frac{2S}{t} - V_o$$

$$V_f = \sqrt{V_o^2 + 2aS}$$

$$V_f = \frac{S}{t} + \frac{1}{2} a t$$

$$V_o = \sqrt{V_f^2 - 2aS}$$

$$V_o = \frac{2S}{t} - V_f$$

$$V_o = V_f - at$$

$$V_o = \frac{S}{t} - \frac{1}{2} a t$$

$$t = \frac{(V_f - V_o)}{a}$$

$$t = \frac{2S}{(V_f + V_o)}$$

$$a = \frac{(V_f^2 - V_o^2)}{2S}$$

$$a = \frac{(V_f - V_o)}{t}$$

$$a = \frac{2(S - V_o t)}{t^2}$$

$$a = \frac{2(V_f t - S)}{t^2}$$

S = Distance
V_f = Final Velocity
V_o = Initial Velocity
a = accelleration
t = time

For Constant Velocity:

$$S = Vt$$

MECHANICS – ANGULAR

$$\theta = \tfrac{1}{2}\alpha t^2$$
$$\theta = \tfrac{1}{2}\omega_f t$$
$$\theta = \frac{\omega_f^2}{2\alpha}$$

$$\omega_f = \alpha t$$
$$\omega_f = \frac{2\theta}{t}$$
$$\omega_f = \sqrt{2\alpha\theta}$$

$$t = \frac{2\theta}{\omega_f}$$
$$t = \sqrt{\frac{2\theta}{\alpha}}$$
$$t = \frac{\omega_f}{\alpha}$$

$$\alpha = \frac{2\theta}{t^2}$$
$$\alpha = \frac{\omega_f^2}{2\theta}$$
$$\alpha = \frac{\omega_f}{t}$$

$$\theta = \omega_0 t + \tfrac{1}{2}\alpha t^2$$
$$\theta = \frac{(\omega_f + \omega_0)t}{2}$$
$$\theta = \frac{(\omega_f^2 - \omega_0^2)}{2\alpha}$$
$$\theta = \omega_f t - \tfrac{1}{2}\alpha t^2$$

$$\omega_f = \omega_0 + \alpha t$$
$$\omega_f = \frac{2\theta}{t} - \omega_0$$
$$\omega_f = \sqrt{\omega_0^2 + 2\alpha\theta}$$
$$\omega_f = \frac{\theta}{t} + \tfrac{1}{2}\alpha t$$

$$\omega_0 = \sqrt{\omega_f^2 - 2\alpha\theta}$$
$$\omega_0 = \frac{2\theta}{t} - \omega_f$$
$$\omega_0 = \omega_f - \alpha t$$
$$\omega_0 = \frac{\theta}{t} - \tfrac{1}{2}\alpha t$$

$$t = \frac{(\omega_f - \omega_0)}{\alpha}$$
$$t = \frac{2\theta}{(\omega_f + \omega_0)}$$

For Const. Angular Velocity

$$\theta = \omega t$$

$$\alpha = \frac{(\omega_f - \omega_0^2)}{2\theta}$$
$$\alpha = \frac{(\omega_f - \omega_0)}{t}$$
$$\alpha = \frac{2(\theta - \omega_0 t)}{t^2}$$
$$\alpha = \frac{2(\omega_f t - \theta)}{t^2}$$

θ = Angular Distance of rotation – radians
ω_f = Final angular velocity – radians/sec
ω_0 = Initial angular vel. – radians/sec
α = angular accelleration – rad/sec/sec
t = time – sec.

WATER CONTENT

$$\%\ \text{water Content} = \frac{Lwt^H - Lwt^D}{Lwt^H} \cdot 100\%$$

$$\%\ \text{water uptake} = \frac{Lwt^H - Lwt^D}{Lwt^D} \cdot 100\%$$

Lwt^H = Weight of fully Hydrated Lens

Lwt^D = Weight of fully Dehydrated Lens.

LOCAL ASPHERIC POWER

$$F_S = \frac{1000(n-1)}{r_0\sqrt{1+e^2y^2/r_0^2}}$$

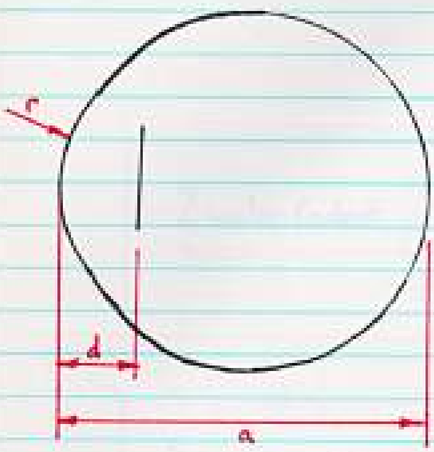
$$F_S = \frac{F_0}{\sqrt{1+e^2y^2/r_0^2}}$$

$$F_T = \frac{F_0 \,.\, r_0^2}{r_0^2 . \left(\sqrt{1+e^2y^2/r_0^2}\right) . \left(1+e^2y^2/r_0^2\right)}$$

$$\angle .Ast = \frac{-F_0\, e^2 y^2}{r_0^2\left(\sqrt{1+e^2y^2/r_0^2}\right)\left(1+e^2y^2/r_0^2\right)}$$

F_S = Sagittal Power
F_T = Tangential Power
$\angle$ Ast. = Local Astigmatism
F_0 = Vertex Power
r_0 = Apical Radius
n = refractive index
y = $\frac{1}{2}$ diam.
e = eccentricity

INTRAOCULAR LENS BASICS



1. Infinately thin lens:

$$D = \frac{1000\,n\,(4r - a)}{(a-d)(4r-d)}$$

D = Dioptre Power of IOL in aqueous or vitreous.
n = Refractive index = 1.336
r = Corneal Radius
a = axial length
d = distance from anterior vertex to IOL

2. Emmetropia

$$D = \frac{1000\,n\,(4r - a)}{(a-d)(4r-d)}$$

3. Ametropia at cornea

$$D = \frac{1000n\,(4r - a - 0.003\,a.r.R_c)}{(a-d)(4r - d - 0.003\,d.r.R_c)}$$

4. Ametropia at vertex

$$D = \frac{1000\,n\,(4r - a - (v(4r-a) + 0.003\,a.r)R_s)}{(a-d)(4r - d - (v(4r-d) + 0.003\,d.r)R_s)}$$

V = Vertex Dist.
R_s = Power Correction at Vertex
R_c = Power Correction at Cornea

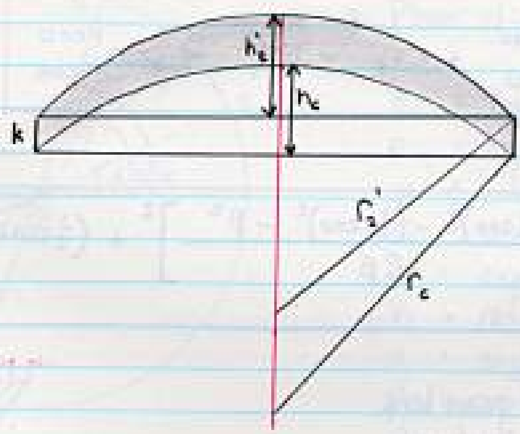
$$R_c = \frac{1000n(4r-a) - D(a-d)(4r-d)}{1000n(0.003\,a.r) - D(a-d)(0.003\,d.r)}$$

$$R_s = \frac{1000\,n(4r-a) - D(a-d)(4r-d)}{n1000(v(4r-a) + 0.003ar) - D(a-d)(v(4r-d) + 0.003\,dr)}$$

TEAR VOLUME

$$h = r - (r^2 - y^2)^{\frac{1}{2}}$$

$$V = \frac{\pi}{3} h_2'^2 \cdot (3r_2' - h_2') + \pi y^2 k - \frac{\pi h_c^2}{3} \cdot (3r_c - h_c)$$



V = Volume of tear lens
r_2' = Radius of lens B.S. - BCOR
h_2' = Sag of BCOR
R_c = Radius of cornea
$2y$ = Diameter
k = edge thickness
h_c = Sag of Cornea.

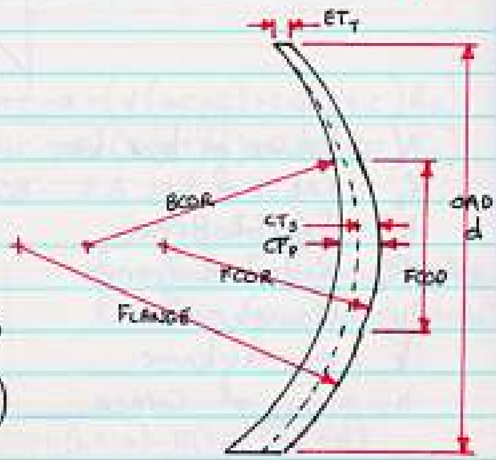
PRISM BALLAST CT + RADII

$$CT_p = CT_s + \frac{d \cdot p}{200(n-1)}$$

$$FCOR = \frac{(n-1)\left(1000 \cdot n \cdot BCOR_1 + CT_p\, BVP_s\, BCOR_1 + CT_p\, 1000(n-1)\right)}{n\left(BVP_s\, BCOR_1 + 1000(n-1)\right)}$$

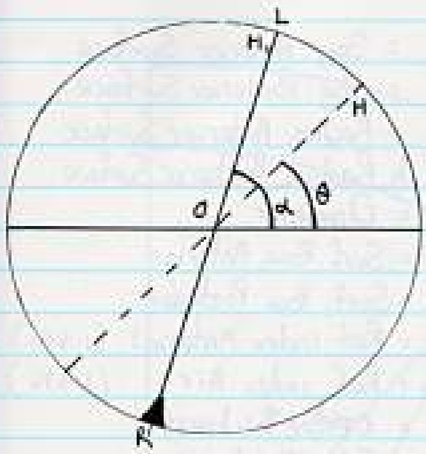
$$\beta = Sag^{OAD}_{BS} + CT_p - ET_T - Sag^{FCOD}_{FCOR}$$

$$FLANGE = \sqrt{\left[\frac{(\frac{1}{2}OAD)^2 - (\frac{1}{2}FCOD)^2 - \beta^2}{2\beta}\right]^2 + (\tfrac{1}{2}OAD)^2}$$



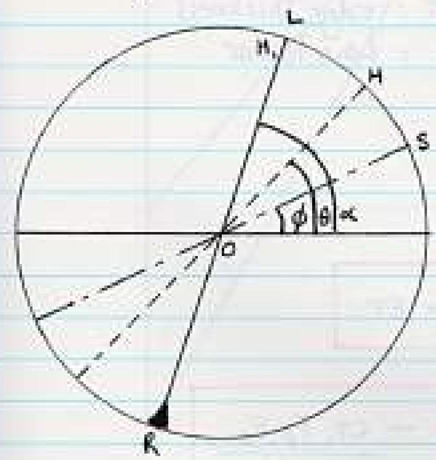
CT_p = Centre thickness of prism lens
CT_s = Centre thickness with ϕ prism
d = Overall Diameter
p = Dioptres of prism
n = Refractive index
FCOR = Front Central Optic Radius
$BCOR_1$ = Flattest Back Central Optic Radius
BVP_s = Spherical Back Vertex Power
ET_T = Edge thickness at apex (thinnest)
OAD = Overall Diameter

EDGE THICKNESS FOR SPHERO-CYL PRISMS



1. Plano Prism

$$e_H = \frac{e_{H_1}}{2}\left(1 + \cos[\alpha - \theta]\right)$$



1. Plano cyl-prism

- e_H = Edge thickness at H
- e_{H_1} = Edge thickness at H_1
- y = ½ diameter
- C = cylinder Power (+ve)
- CT = centre thickness
- n = refractive index
- α = angle of prism
- ϕ = angle of +ve cyl
- θ = angle to measure

$$e_H = \frac{e_{H_1}}{2}\left(1 + \cos[\alpha + \phi]\right) + CT - \frac{y^2 C}{2000(n-1)} \cdot \sin^2(\theta - \phi)$$

INTRAOCULAR LENS POWER

$$S_A = R_A - \sqrt{R_A^2 - \left(\tfrac{1}{2}D\right)^2}$$

$$S_P = R_P - \sqrt{R_P^2 - \left(\tfrac{1}{2}D\right)^2}$$

$$F_A = \frac{1000.(N_L - N_A)}{R_A}$$

$$F_P = \frac{1000\,(N_L - N_A)}{R_P}$$

S_A = Sag. Anterior Surface
S_P = Sag Posterior Surface
R_A = Radius Anterior Surface
R_P = Radius Posterior Surface
D = Diameter
F_A = Surf. Pow. Anterior
F_P = Surf. Pow Posterior
N_L = Ref. Index Material (1.491)
N_A = Ref index Air (1.336)
CT = Centre Thickness
ET = Edge Thickness
F = Lens Power

1. BICONVEX

$$CT = S_A + S_P + ET$$

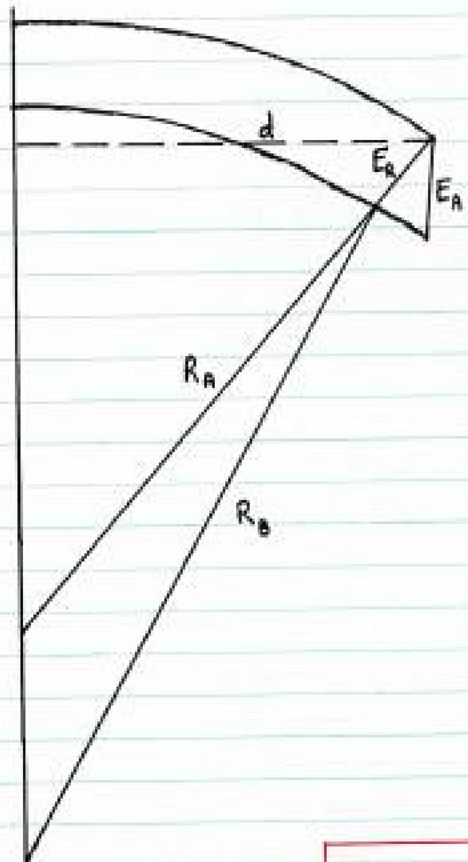
$$F = F_A + F_P - \frac{CT.\,F_P.F_A}{1000.N_L}$$

2. PLANO-CONVEX

$$CT = S_A + ET$$

$$F = F_A$$

RADIAL + AXIAL THICKNESS

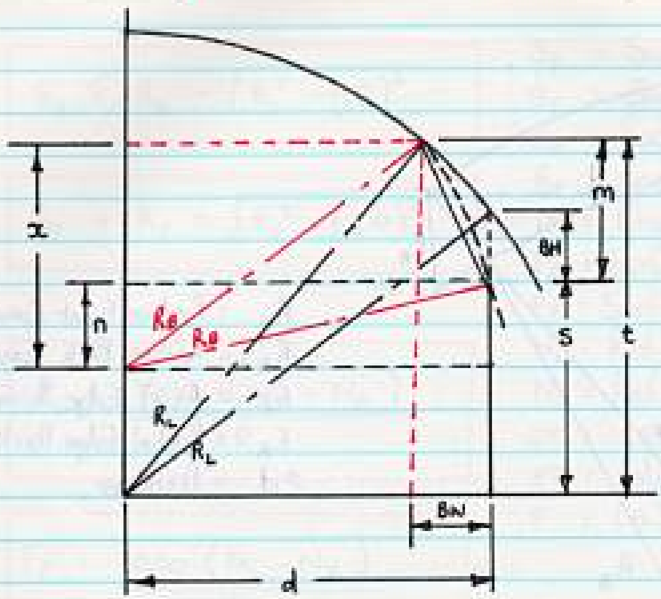


R_A = Radius Front Curve
R_B = Radius Back Curve
E_A = Axial Edge Thickness
E_R = Radial Edge Thickness
$2d$ = Diameter.

$$x = R_B - R_A + E_A$$

$$E_R = \frac{\sqrt{\left(x\sqrt{R_A^2 - d^2} - R_A^2\right)^2 - R_A^2\left(x^2 - R_B^2 + R_A^2 + 2x\sqrt{R_A^2 - d^2}\right)} + \left(x\sqrt{R_A^2 - d^2} - R_A^2\right)}{R_A}$$

CC AXIAL RADII



$$t = \sqrt{R_L^2 - (d - BW)^2}$$

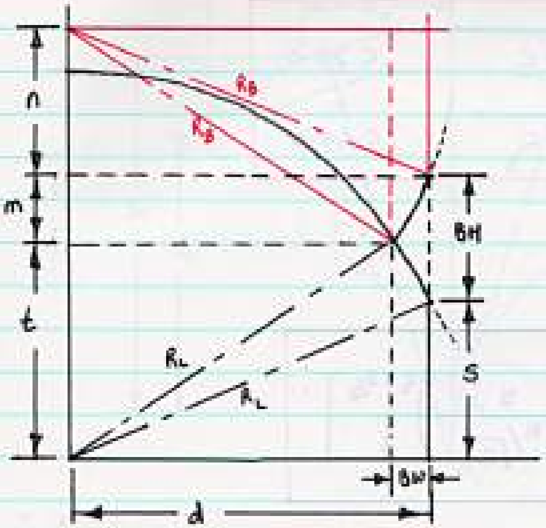
$$s = \sqrt{R_L^2 - d^2} - BH$$

$$m = t - s$$

$$R_B = \sqrt{d^2 + \left[\frac{2dBW - BW^2 - m^2}{2m}\right]^2}$$

$$BH = \sqrt{R_L^2 - d^2} - \sqrt{R_L^2 - (d - BW)^2} + \sqrt{R_B^2 - (d - BW)^2} - \sqrt{R_B^2 - d^2}$$

CX AXIAL RADII



$$t = \sqrt{R_L^2 - (d - BW)^2}$$

$$s = \sqrt{R_L^2 - d^2}$$

$$m = BH + s - t$$

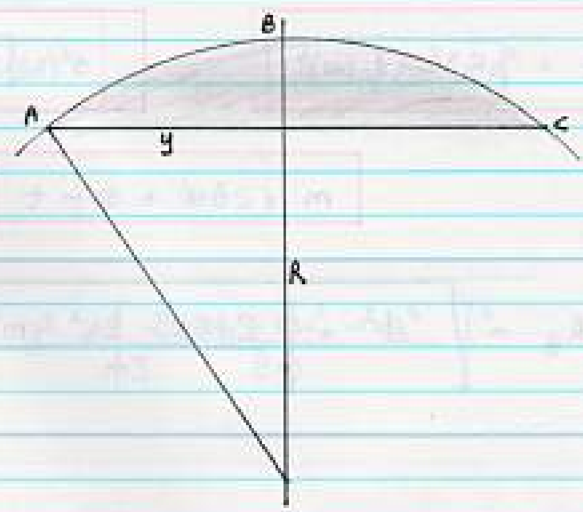
$$R_B = \sqrt{d^2 + \left[\frac{2dBW - BW^2 - m^2}{2m}\right]^2}$$

CONIC VOLUMES

$$e = \sqrt{1 - c} \qquad c > 0.0$$

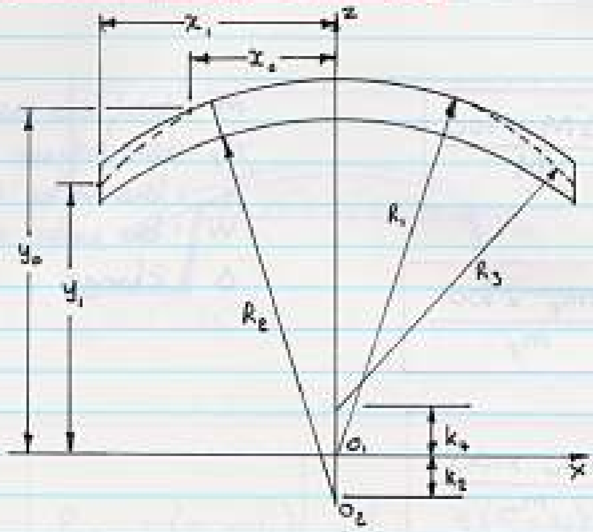
$$e = \sqrt{1 + c} \qquad c < 0.0$$

$$V = \frac{2\pi R^3}{3c^2}\left[1 - \left\{1 - \left(\frac{y}{R/\sqrt{c}}\right)^2\right\}^{3/2}\right]$$



V = Volume $\overline{ABC}$
R = Apical Radius
C = Shape Factor
y = $\frac{1}{2}$ diameter
e = eccentricity.

VOLUME OF SPHERO-ASPHERE LENTIC LENS



V_A = Volume of lens

V_1, V_2, V_3, V_4 } Partial Volumes

R_1 = Anterior Radius

R_2 = Posterior Apical Rad

R_3 = F.S. Flange Rad.

x_0 = ½ FCOD

x_1 = ½ OAD

c = shape factor

e = eccentricity

k_2, k_4 = Origin Displacement

$$V_1 = \frac{2\pi R_1^3}{3}\left[1-\left\{1-\left(\frac{x_0}{R_1}\right)^2\right\}^{3/2}\right]$$

$$e = \sqrt{1-c} \qquad c > 0.0$$
$$e = \sqrt{1+c} \qquad c < 0.0$$

$$V_2 = \frac{2\pi R_2^3}{3c^2}\left[1-\left\{1-\left(\frac{x_1}{R_2/\sqrt{c}}\right)^2\right\}^{3/2}\right] + x_1^2 \pi k_2$$

$$V_3 = \frac{\pi}{4R_2} x_1^4 + \pi x_1^2 k_2$$

$$V_4 = \frac{2\pi R_3^3}{3}\left[\left\{1-\left(\frac{x_0}{R_3}\right)^2\right\}^{3/2} - \left\{1-\left(\frac{x_1}{R_3}\right)^2\right\}^{3/2}\right] + \pi k_4\left(x_1^2 - x_0^2\right)$$

$$V_A = V_1 + V_4 - V_2 \quad \text{or} \quad V_A = V_1 + V_4 - V_3 \ \text{ for } c = 0.0$$

HYDRATION DEFINITIONS

$$\% \Delta M = \frac{\Delta M \times 100}{M}$$

$$\% \Delta m_p = \frac{\Delta m_p \times 100}{m_p}$$

$$\% \Delta m_w = \frac{\Delta m_w \times 100}{m_w}$$

$$\% \Delta W = \frac{\Delta W \times 100}{W}$$

M = total lens mass
m_p = lens polymer mass
m_w = lens water mass
W = lens water content
Δ = change

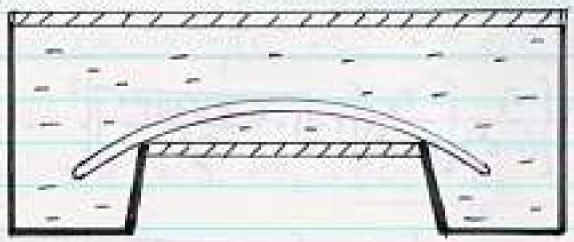
$$\Delta W = \frac{\% \Delta M (100 - W)}{100 + \% \Delta M}$$

$$\Delta W = \frac{W \times \% \Delta m_w (100 - w)}{10000 + \% \Delta m_w \times W}$$

$$\% \Delta W = \frac{100 \times \% \Delta M (100 - W)}{W (100 + \% \Delta M)}$$

$$\% \Delta W = \frac{100 \times \% \Delta m_w (100 - w)}{10000 + (\% \Delta m_w \times w)}$$

BVP - WET CELL TO AIR



$$P_{wc} = (n_L - n_c)\left[\frac{1}{r_1\left[1 - \frac{t(n_L - n_c)}{n_L r_1}\right]} - \frac{1}{r_2}\right]$$

$$P_a = (n_L - 1)\left[\frac{\frac{P_{wc}}{(n_L - n_c)} + \frac{t(n_L - 1)}{n_L r_2}\left[\frac{P_{wc}}{(n_L - n_c)} + \frac{1}{r_2}\right]}{1 - \frac{t(n_L - 1)}{n_L}\left[\frac{P_{wc}}{(n_L - n_c)} + \frac{1}{r_2}\right]}\right]$$

P_a = BVP in air
P_{wc} = BVP in wet cell
n_L = ref. index of lens
n_c = ref. index of saline
n_w = ref. index of window

t = ct of lens
r_1 = first radius of curvature
r_2 = second radius

ASPHERIC VOLUMES

$$V_{as} = \pi(1-e^2)\left\{\frac{r_s}{(1-e^2)}\left\{\frac{r_s}{(1-e^2)}\left[1-\sqrt{1-\frac{(1-e^2)(d/2)^2}{r_s^2}}\right]\right\}^2 - \frac{1}{3}\left[\frac{r_s}{(1-e^2)}\left[1-\sqrt{1-\frac{(1-e^2)(d/2)^2}{r_s^2}}\right]\right]^3\right\}$$

V_{as} = Volume Aspere
r_s = Apical Radius
d = chord diameter
e = eccentricity

$$p = (1-e^2)$$
$$y = d/2$$

$$V_{as} = p\pi\left[\frac{r_s}{p}\left[\frac{r_s}{p}\left[1-\sqrt{1-\frac{py^2}{r_s^2}}\right]\right]^2 - \frac{1}{3}\left[\frac{r_s}{p}\left[1-\sqrt{1-\frac{py^2}{r_s^2}}\right]\right]^3\right]$$

CROSS CYLS

$$C_R = \text{RESULTANT CYL} = -\sqrt{\left(C_1^2 + C_2^2 + 2 . C_1 C_2 \cos\left(2\left(A_1 - A_2\right)\right)\right)}$$

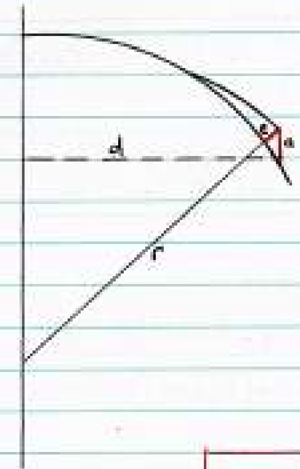
$$S_R = \text{RESULTANT SPH} = S_1 + S_2 + \frac{\left(C_1 + C_2 - C_R\right)}{2}$$

$$A_R = \text{RESULTANT AXIS} = A_1 + \tfrac{1}{2}\,\text{ATAN}\left[\frac{C_2 . \sin\left(2\left(A_1 - A_2\right)\right)}{C_1 + \left(C_2 . \cos\left(2\left(A_1 - A_2\right)\right)\right)}\right]$$

S_1 = Sph Power 1	C_1 = cyl power 1	A_1 = Axis 1
S_2 = Sph Power 2	C_2 = cyl power 2	A_2 = Axis 2

S_R = Res Sph	C_R = Res Cyl	A_R = Res Axis

AXIAL + RADIAL EDGE LIFT



$$e = \sqrt{\left(a + \sqrt{r^2 - d^2}\right)^2 + d^2} - r$$

$$a = Sag_{r}^{2d} - Sag_{BS}^{2d}$$

e = radial edge lift
a = axial edge lift
r = apical radius (BS)
d = ½ diameter

Sag_{r}^{2d} = Sag apical Radius at 2d
Sag_{BS}^{2d} = Sag Back Surface at 2d