Formulas, Laws and Numbers in Optometry, Ophthalmology & Vision Science

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Basics

1.1 Trigonometry

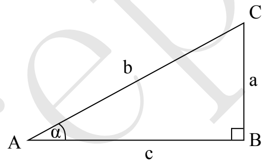


Figure 1.1: **Right Triangle**

$$sin\alpha = \frac{a}{b} \tag{1.1}$$

$$cos\alpha = \frac{c}{b} \tag{1.2}$$

$$tan\alpha = \frac{a}{c} \tag{1.3}$$

1.2 Angular Measure

1.2.1 Degree to Radian

$$alpha_{Radian} = \frac{\alpha_{Degree} \cdot \pi}{180} \tag{1.4}$$

1.2.2 Radian to Degree

$$alpha_{Degree} = \frac{\alpha_{Radian} \cdot 180}{\pi} \tag{1.5}$$

Angular Measurements

1° = 60' [arc min]
1' = 60" [arc sec]

1.3 The Metric System

Table 1.1: The Metric System

Prefix	Symbol	Power	Factor
Exa	E	10^{18}	1,000,000,000,000,000,000
Peta	P	10^{15}	1,000,000,000,000,000
Tera	T	10^{12}	1,000,000,000,000
Giga	G	10^{9}	1,000,000,000
Mega	M	10^{6}	1,000,000
Kilo	k	10^{3}	1,000
Hecto	h	10^{2}	100
Deca	da	10^{1}	10
non	non	10^{0}	1
Deci	d	10^{-1}	0.1
Centi	c	10^{-2}	0.01
Milli	m	10^{-3}	0.001
Micro	μ	10^{-6}	0.000,001
Nano	n	10^{-9}	0.000,000,001
Pico	p	10^{-12}	0.000,000,000,001
Femto	f	10^{-15}	0.000,000,000,000,001
Atto	A	10^{-18}	0.000,000,000,000,000,001

1.4 International System of Units

Table 1.2: International System of Units (SI)

Unit Name	Unit Symbol	Dimension Symbol	Quantity name
metre	m	L	length
kilogram	kg	M	mass
second	s	T	time
ampere	A	I	electric current
kelvin	K	Θ	thermodynamic temperature
mole	mol	N	amount of substance
candela	cd	J	luminous intensity

Chapter 2

Optics

2.1 Nature of Light

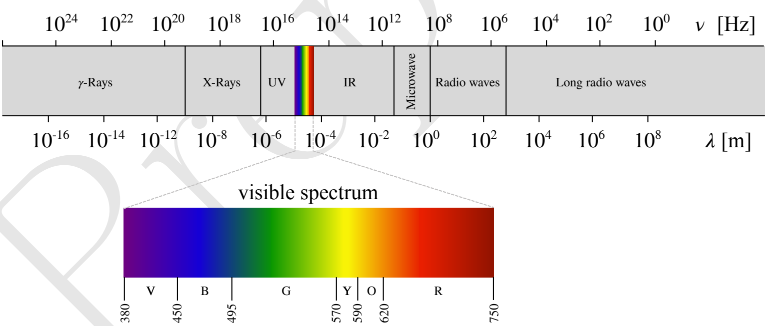


Figure 2.1: **Electromagnetic Radiation**

$$V = \nu \cdot \lambda \tag{2.1}$$

V: Velocity $[ms^{-1}]$

ν: Frequency $[s^{-1} = Hz]$
λ: Wavelength $[m]$

$$E = h \cdot \nu \tag{2.2}$$

$$E = \frac{h \cdot c}{\lambda} \tag{2.3}$$

E: Photon Energy
h: Planck Constant $(6.626070040 \cdot 10^{34} Js)$
c: Speed of light $(299792458 ms^{-1})$

2.2 Reflection

2.2.1 Reflection on plane surfaces

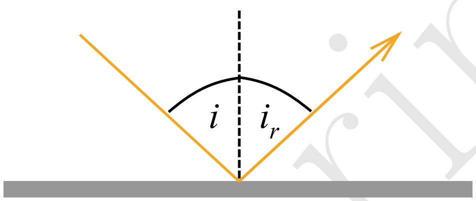


Figure 2.2: **Reflection on plane surfaces**

i: Angle of incidence
i_r: Angle of reflection

Law of Reflection:

$$i = i_r \tag{2.4}$$

2.2.2 Reflection on curved surfaces

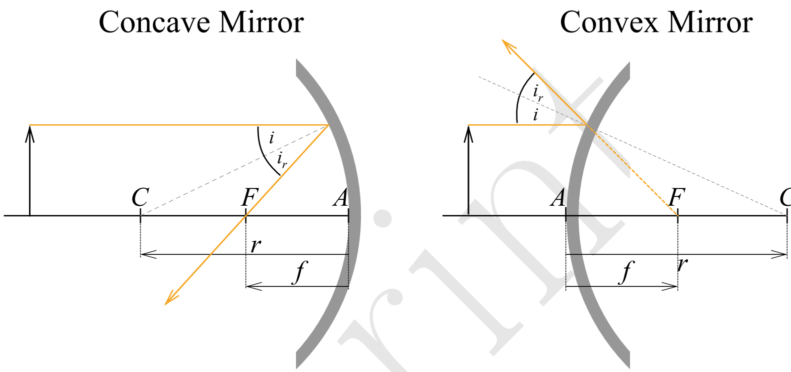


Figure 2.3: **Reflection on curved surfaces**

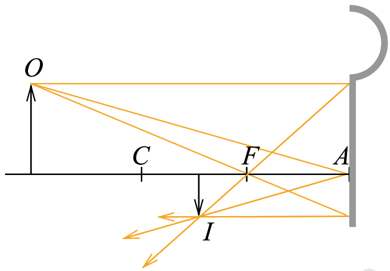
C: Centre of curvature
F: Focus point
A: Pole / Vertex
r: Radius
f: Focal length

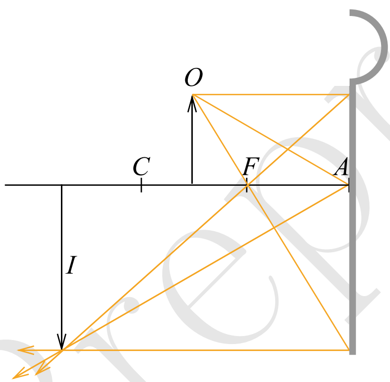
$$f = \frac{r}{2} \tag{2.5}$$

$$F_r = -\frac{n}{f} \tag{2.6}$$

F_r: Reflective power of the mirror
n: Refractive index of medium surrounding the mirror

Concave mirrors





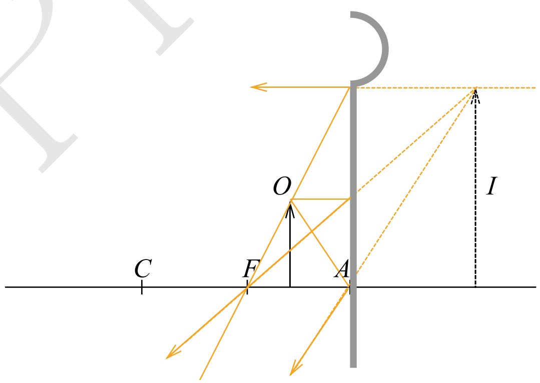
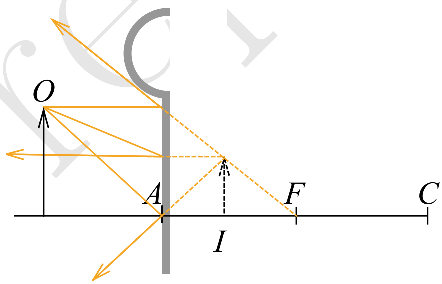


Table 2.1: Image formation at curved mirrors

Type of mirror	Object position	Image position	Nature of image	Size of image
Concave	$< f$	behind the mirror	virtual, upright	larger
Concave	at F	at ∞		
Concave	between C & F	between C & ∞	real, inverted	larger
Concave	at C	at C	real, inverted	same
Concave	between $2f$ & ∞	between f & $2f$	real, inverted	smaller
Concave	at ∞	at F	real, inverted	
Convex	all positions	behind the mirror	virtual upright	smaller

Convex mirrors



2.2.3 Important equations

$$F_r = L' - L$$

$$L = \frac{n}{l}$$

$$L' = -\frac{n}{l'}$$

$$F_r = -\frac{n}{f}$$

$$f = \frac{r}{2}$$

n: Refractive index of medium surrounding the mirror
L: Vergence in
L': Vergence out
l: Distance to object
l': Distance to image
F_r: Reflective power of the mirror
f: Focal length
n: Refractive index surrounding the mirror
r: Radius of curvature

2.3 Refraction

2.3.1 Refractive Index (n)

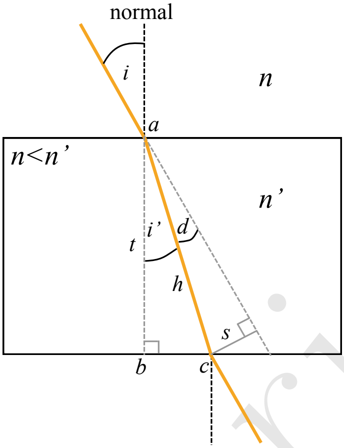
$$n = \frac{c_1}{c_2}$$

c_1: Speed of light outside the medium
c_2: Speed of light in the medium

Table 2.2: Important refractive indices

Material	Refractive Index n
Air	1
Water	1.333
CR-39	1.498
Crown Glass	1.523
Trivex	1.532
Polycarbonate	1.586

2.3.2 Snell's Law



n: Refractive index of primary medium
n': Refractive index of secondary medium
t: Thickness or width of medium
i: Angle of incidence
i': Angle of refraction
d: Angle of deviation
h: Length of refracted ray
s: Lateral displacement

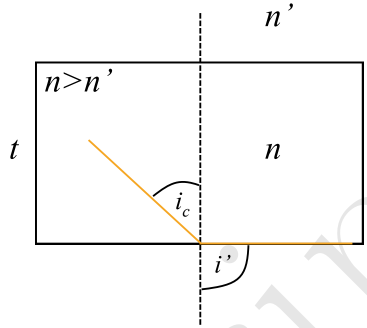
Snell's Law

$$sini \cdot n = sini' \cdot n'$$

$$\frac{sini}{sini'} = \frac{n'}{n}$$

$$i' = sin^{-1}\left(\frac{n \cdot sini}{n'}\right)$$

2.3.3 Total Internal Reflection

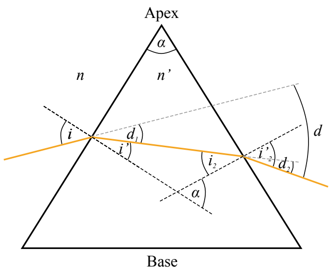


$$sin i_c = \frac{n'}{n}$$

$$i_c = sin^{-1}\frac{n'}{n}$$

i_c: Critical angle

2.3.4 Refraction by Prisms



Total Deviation d:

$$d = d_1 + d_2$$

or

$$d = (i + i'_2) - \alpha$$

The minimum angle of deviation occurs when the angle of incidence at the first surface (i) is equal to the angle of refraction at the second surface (i'_2) ($i = i'_2$) .

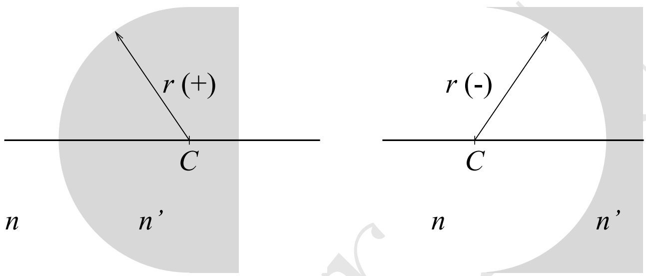
$$\frac{n'}{n} = \frac{sin\frac{\alpha+d_{min}}{2}}{sin\frac{\alpha}{2}}$$

or

$$d_{min} = i - \alpha + sin^{-1}\left(n' \cdot sin\left(\alpha - sin^{-1}\left(\frac{sini}{n'}\right)\right)\right)$$

2.3.5 Refraction on curved surfaces

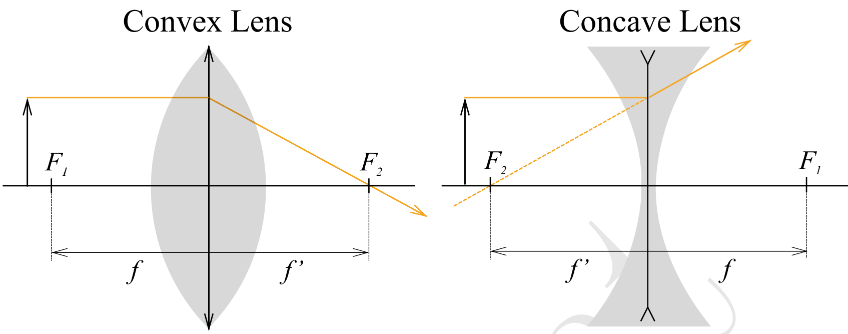
Sign Convention



Calculating the power at curved surfaces

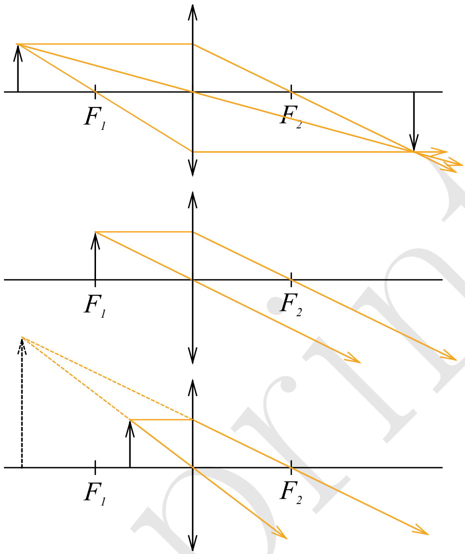
$$F = \frac{n' - n}{r}$$

F: Refractive power
n: Refractive index of surrounding medium
n': Refractive index of material



f: First focal length / object focal length
f': Second focal length / image focal length
F_1: Primary focal point
F_2: Secondary focal point

Convex Lenses



Concave Lenses

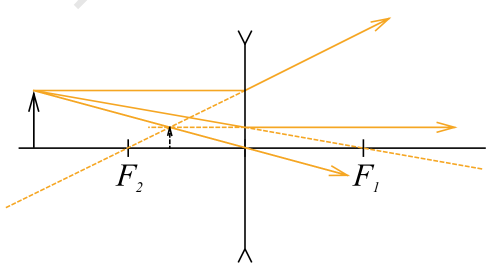


Table 2.3: Image formation at lenses

Type of lens	Object position	Image position	Nature of image	Size of image
Converging	$< f$	same side of lens	virtual, upright	larger
Converging	at F_1	at ∞		
Converging	between f & $2f$	between $2f'$ & ∞	real, inverted	larger
Converging	at $2f$	at $2f'$	real, inverted	same
Converging	between $2f$ & ∞	between f' & $2f'$	real, inverted	smaller
Converging	at ∞	at F_2	real, inverted	
Diverging	$< \infty$	$< f'$	virtual, upright	smaller
Diverging	at ∞	at F_2	virtual	

2.3.6 Important equations

Single surfaces

$$F = -\frac{n}{f}$$

$$F = \frac{n'}{f'}$$

$$-\frac{n}{f} = \frac{n'}{f'}$$

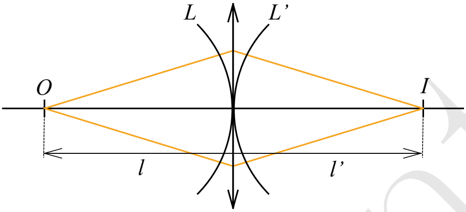
$$\frac{f}{f'} = -\frac{n}{n'}$$

F: Refractive power of the lens

Thin lenses

$$f = -f'$$

2.4 Step along method

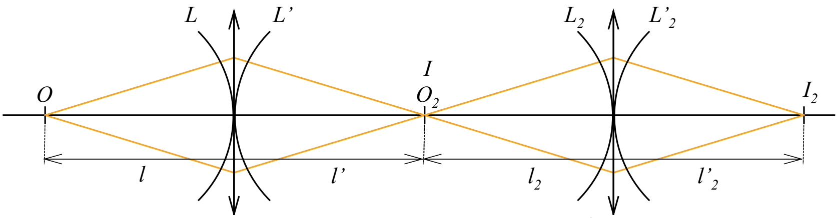


$$F = L' - L$$

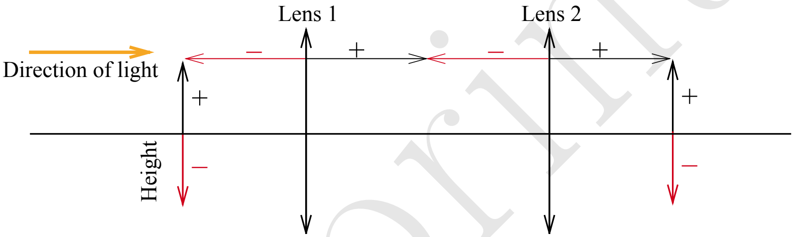
$$L = \frac{n}{l}$$

$$L' = \frac{n'}{l'}$$

L: Vergence IN (D)
L': Vergence OUT (D)
l: Distance to object (m)
l': Distance to image (m)
F: Power (D)
n: Refractive index surrouding
n': Refractive index surrouding



Sign convention



2.4.1 The power of a lens system

Back vertex power

$$F'_v = \frac{F_{1st} + F_{2nd} - d \cdot F_{1st} \cdot F_{2nd}}{1 - d \cdot F_{1st}}$$

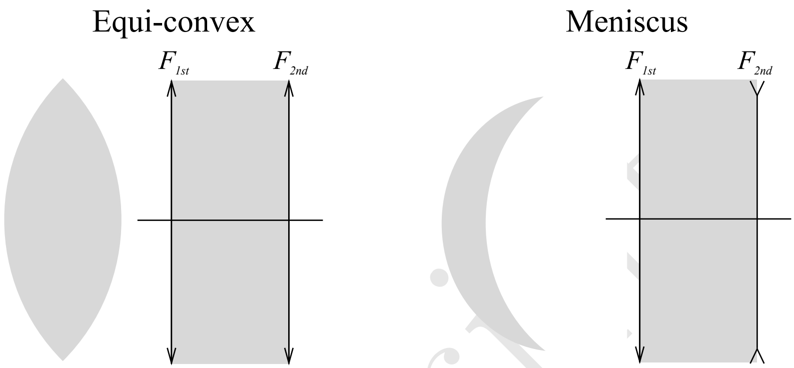
F'_v: Back vertex power (D)
F_{1st}: Power of the first lens (D)
F_{2nd}:Power of the second lens (D)
d: Distance between the two lenses (m)

Front vertex power

$$F_v = \frac{F_{1st} + F_{2nd} - d \cdot F_{1st} \cdot F_{2nd}}{1 - d \cdot F_{2nd}}$$

F_v: Front vertex power (D)
n: Refractive index

2.5 Thick lenses



2.5.1 Power of thick lens

Back vertex power

$$F_{v'} = \frac{F_{1st} + F_{2nd} - \left({}^{d}\!/\!_{n'}\right) \cdot F_{1st} \cdot F_{2nd}}{1 - \left({}^{d}\!/\!_{n'}\right) \cdot F_{1st}}$$

$$f'_v = \frac{n'}{F'_v}$$

F'_v: Back vertex power (D)
f'_v: Second focal length (distance from back lens to second focal point)

F_{1st}: Power of the first lens (D)
F_{2nd}:Power of the second lens (D)
d: Distance between the two surfaces (m)
n': Refractive index of lens material

Front vertex power

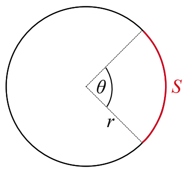
$$F_v = \frac{F_{1st} + F_{2nd} - (d/n') \cdot F_{1st} \cdot F_{2nd}}{1 - (d/n') \cdot F_{2nd}}$$

$$f_v = -\frac{n}{F_v}$$

F_v:Front vertex power (D)
f_v: First focal length (distance from front lens to first focal point)
n: Refractive index outside of lens

2.6 Photometry

2.6.1 Flat angles

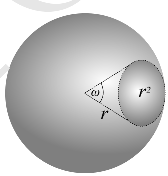


Radian is the angle subtended at the centre of a circle by an arc equal to its radius.

$$\theta = \frac{S}{r}$$

2.6.2 Solid angles

Complete angle (360°), in radians, surrounding a point (2-dimensionally) would be given by 2π.



The unit of a solid angle, the *steradian* (ω), is given by:

$$\omega = \frac{A}{r^2}$$

The *Luminous intensity* (I) is the 'strength' of the source in a given direction. One *Candela* (cd) is $1/60$ of I from 1 cm^2 of the surface of platinum at its freezing point (ca. 1773°C), see Black Body Radiation.
The *Luminous Flux* (Φ) is the rate of flow of light energy from a point source.

$$\Phi = \omega \cdot I$$

where ω is the solid angle into which the light flows from the point source of intensity I. The unit of flux is *Lumen*.

The *Illuminance* (E), is the measure of the luminous flux density at a point on an illuminated surface.

$$E = \frac{\Phi}{A} \qquad \left[\frac{Lumen}{m^2} = Lux\right]$$

The *Luminance* (L) is the amount of light per unit area emitted or reflected in a given direction by a surface [cd/m^2].

2.6.3 Inverse Square Law

$$E = \frac{I}{r^2}$$

2.6.4 Cosine Law

$$E = \frac{I}{r^2} \cos\theta$$

2.7 Optical Instruments

2.7.1 Camera

f-number

$$f/\# = \frac{f}{D}$$

f: Focal length
D: Diameter of stop

Depth of Focus

The *Depth of focus* (d) of a lens or lens system is the total axial range over which the image plane can me moved without noticable deterioration in the image definition.

$$d = \frac{f}{1000}$$

Depth of Field

The *Depth of field* (DoF) is the distance between the axial positions of an object for which it is tolerably in focus on a fixed object plane.

$$DoF = \frac{2 \cdot l^2 \cdot d}{l' \cdot D}$$

2.7.2 Magnification - The Simple Magnifier

Linear Magnification (LM)

$$LM = \frac{h'}{h} = \frac{l'}{l} = \frac{L}{L'}$$

Angular Magnification (MA)

$$MA = \frac{\beta}{\alpha}$$

α: Angle subtended at unaided eye by object at least distance of distinct vision ($q = -0.25m$)
β: Angle subtended at eye by image produced by lens

$$MA = \frac{q \cdot L}{1 - d \cdot L'}$$

Nominal Angular Magnification (MA_{nom})

$$MA_{nom} = \frac{F}{4}$$

Maximum Angular Magnification (MA_{max})

$$MA_{max} = 1 + \frac{F}{4}$$

Iso-accommodative Magnification (MA_{iso})

$$MA_{iso} = 1 + 0.15 \cdot F$$

Magnification of a telescope (M_T)

$$M_T = -\frac{F_E}{F_O} = -\frac{f_O}{f'_E}$$

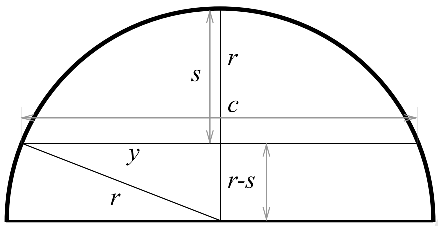
F_E: Power of eyepiece
f_E: Focal length of eyepiece
F_O: Power of objective
f_O: Focal length of eobjective

2.7.3 Entrance and Exit Pupils

$$M = -\frac{D}{D'}$$

D: Diameter of entrance pupil
D': Diameter of exit pupil

2.8 Calculating the Sag



s: Sag
r: Radius
c: Chord

$$y = \frac{1}{2} \cdot c$$

$$r = \frac{y}{2 \cdot s} + \frac{s}{2}$$

$$s = r - \sqrt{r^2 - y^2}$$

2.9 Lens meter equation

The lens meter assumes a refractive index of 1.523. If we want to use the lens meter on a lens made of a different material with known refractive index then we need to convert the results using the following equation.

$$F_T = F_{LM} \cdot \frac{n-1}{0.523}$$

F_T: True lens surface power
F_{LM}: Surface power calculated by lens meter
n: Refractive index of the lens

2.10 Toric Lenses

2.10.1 Toric Transposition

Normally a toric lens will have only one toric surface.
The convention for lens specification for front surface toric lenses (plus base) is:

$$\frac{base\ curve\ X\ axis/cross\ curve\ X\ axis}{sphere\ curve}$$

The convention for lens specification for back surface toric lenses (minus base) is:

$$\frac{sphere\ curve}{base\ curve\ X\ axis/cross\ curve\ X\ axis}$$

Spherical Equivalent

Spherical Equivalent (E_{sph})

$$E_{sph} = Sph + \frac{Cyl}{2}$$

2.10.2 Oblique Crossed Cylinders

Calculation Method

Step 1: Convert the prescriptions into the same sph-cylinder form (either negative or positive)
Step 2: Find the difference between the two axis angles (Important: cyl_1 smaller axis, cyl_2 larger axis)
Step 3: Calculate the axis of the new cylinder

$$tan2\theta = \frac{|F_{cyl_2}|sin2\alpha}{|F_{cyl_1}| + |F_{cyl_2}|cos2\alpha}$$

F_{cyl_1}: Power of cyl_1
F_{cyl_2}: Power of cyl_2
θ: Difference to cyl_1
α: Difference between the two cylinder axis

Step 4: Calculate the new cylinder axis and add θ to the first cylinder axis
Step 5: Find the sphere power S caused by the obliquely crossed cylinder:

$$S = F_{cyl_1} sin^2\theta + F_{cyl_2} sin^2(\alpha - \theta)$$

Step 6: Find the new cylindrical power C:

$$C = F_{cyl_1} + F_{cyl_2} - 2S$$

Step 7: Find the total sphere power S_{total} by adding the sphere powers from the original lenses to the sphere power resulting from the cross cylinder:

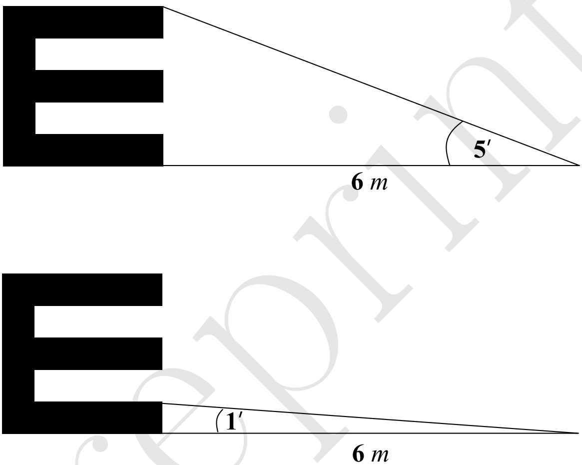
$$S_{total} = S + S_1 + S_2$$

2.11 Accommodation & Vergence

2.11.1 Accommodation

2.11.2 Vergence

2.12 Visual Acutiy



$$VA = \frac{D'}{D}$$

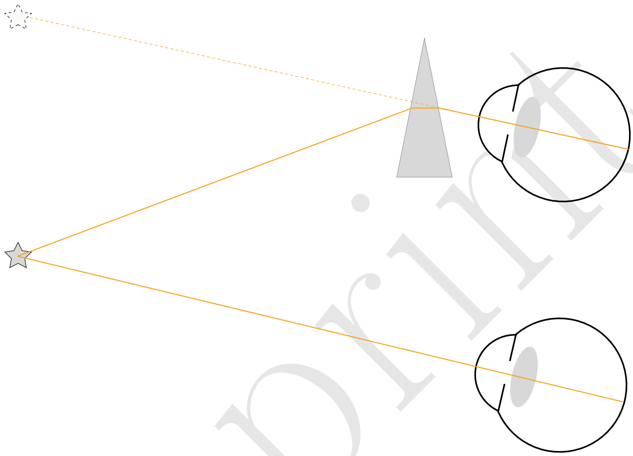
VA: Visual acuity
D': Standard viewing distance (6 m, or 20 ft)
D: Distance at which the optotype subtends 5' (each element or gap subtends 1')

Table 2.4: Visual Acuity Scales

MAR	LogMAR	VAR	Snellen (Metric)	Snellen (Imperial)	Decimal
0.50	-0.30	115	6/3	20/10	2.00
0.63	-0.20	110	6/3.8	20/12.5	1.60
0.80	-0.10	105	6/4.8	20/16	1.25
1.00	0.00	100	6/6	20/20	1.00
1.25	0.10	95	6/7.5	20/25	0.80
1.60	0.20	90	6/9.5	20/32	0.63
2.00	0.30	85	6/12	20/40	0.50
2.50	0.40	80	6/15	20/50	0.40
3.20	0.50	75	6/19	20/63	0.32
4.00	0.60	70	6/24	20/80	0.25
5.00	0.70	65	6/30	20/100	0.20
6.30	0.80	60	6/38	20/125	0.16
8.00	0.90	55	6/48	20/160	0.125
10	1.00	50	6/60	20/200	0.10
20	1.30	35	6/120	2/400	0.05
40	1.60	20	6/240	20/800	0.025
100	2.00	0	6/600	2/2000	0.01

MAR: Minumum Angle of Resolution
LogMAR: $log_{10}MAR$
VAR (Visual Acuity Rating): VAR = $100-(50 \cdot log_{10}MAR)$

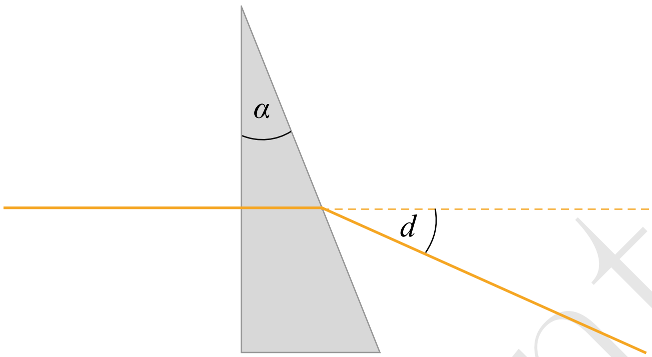
2.13 Prisms



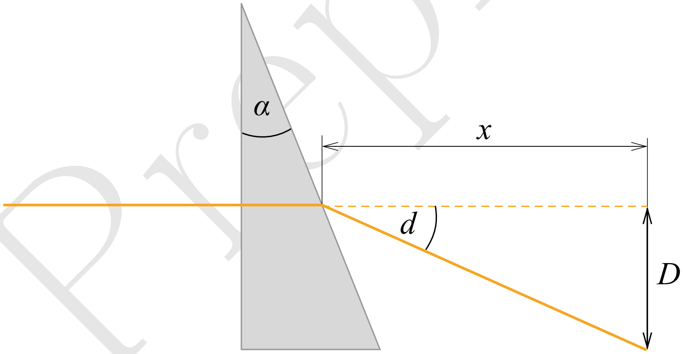
2.13.1 Prism Dioptre

For a thin lens, the angle of deviation d (the difference in the angle at which the light travels following passing through the prism) is given by:

$$d = (n - 1) \cdot \alpha$$



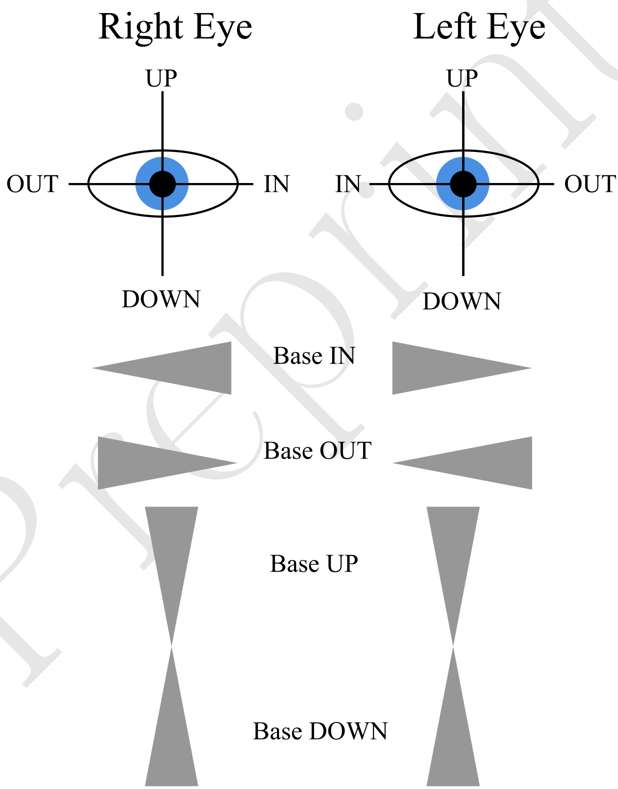
The *Prism Dioptre* $^{\Delta}$ is the amount that light is displaced by a prism when measured on a flat screen. P is the number of centimetres an image is displaced at a distance of 100 cm. Note that the unit is $^{cm}/_{m}$.



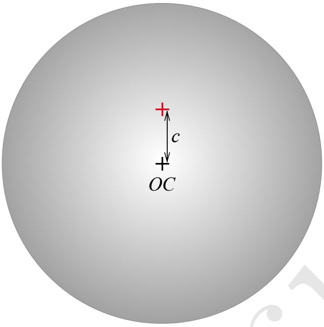
$$P = \frac{D}{x} \quad [^{\Delta}]$$

2.13.2 Prism Notation

The prism direction is described according to where the base is located in relation to the eye.



2.13.3 Prentice Rule



OC: Optical centre
c: Decentration (distance of optical center [cm])

The prismatic effect P of a lens at any given point can be calcuated by the following equation:

$$P = c \cdot F$$

P: Prism power ($^{\Delta}$)
F: Lens power [D]

2.13.4 The prismatic effect of a sphero-cylindrical lens

Horizontal prismatic power

$$H = x \cdot S + C \cdot (y \cdot sin\theta \cdot cos\theta + x \cdot sin^2\theta)$$

Vertical prismatic power

$$V = y \cdot S + C \cdot (x \cdot sin\theta \cdot cos\theta + y \cdot sin^2\theta)$$

H: Horizontal prismatic power
V: Vertical prismatic power $[D]$
x: horizontal decentration
y: vertical decentration
S: Sphere power
C: Cylinder power
θ: Cylinder axis

2.14 Lens Materials

2.14.1 Abbe Number

The Abbe number or V-value V_d of an ophthalmic lens material affects off-axis vision. The Abbe number is an optical property of the material rather than a mechanical characteristic. The refractive index of a material varies with the wavelength of the incident light. The Abbe number of a material also varies with the wavelength of the incident light.

Light	Wavelength [nm]	Refractive Index
yellow	587.6	$n_d = 1.500$
red	656.3	$n_C = 1.496$
blue	486.1	$n_F = 1.505$

$$V_D = \frac{n_d - 1}{n_F - n_C}$$

2.14.2 Transverse Chromatic Aberration

In spectacle lenses, the visual effect of dispersion is called transverse chromatic aberration (TCA). TCA spreads the retinal image parallel to the base-apex line of the prismatic effect. This results in colour fringes with high contrast targets and off-axis blur in conditions of low contrast.

$$TCA = \frac{c \cdot F}{V}$$

Reflectivity

The *Reflectivity* is a measure of amount of surface reflection that occurs.

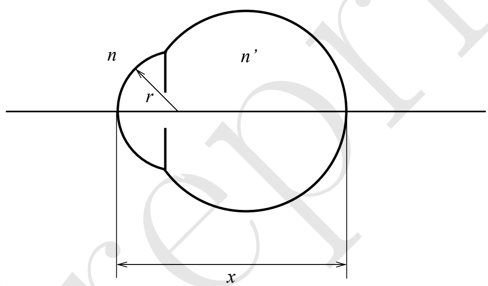
$$r_f = \left(\frac{n' - n}{n' + n} \right)$$

r_f: Reflection factor

2.15 Eye models

2.15.1 Gullstrand's Reduced Schematic Eye

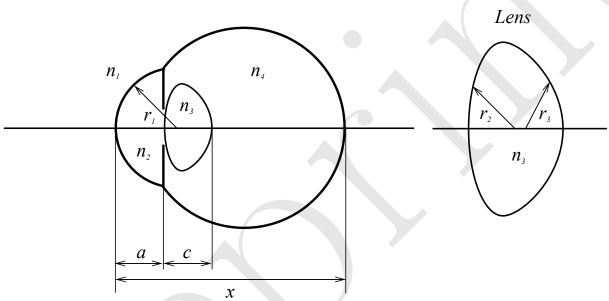
Gullstrand's Reduced Schematic Eye assumes only one refracting surface (Cornea). The Reduced Schematic Eye has the same refractive power as the *Simplified Schematic Eye* and the *Exact Schematic Eye* (see below). It consists of a single refractive surface separating air from the eye. The power of refractive surface is $+60\ D$ with a radius of curvature of $+5.56\ mm$ (Remember: $F = \frac{n'-n}{r}$), where $n = {}^4/_3$ and the axial length (length of the eye) $x = 22.22$ mm.



Dimensions	$[mm]$
Axial Length (x)	22.22
Radii	$[mm]$
Cornea (r)	5.56
Refractive Indices	n
Eye (n')	$^4/_3$

2.15.2 Gullstrand's Simplified Schematic Eye

Gullstrand's Simplified Schematic Eye assumes only three refracting surface (Cornea, front & back surface of lens).

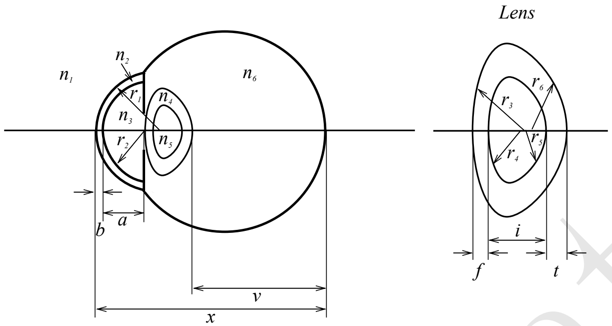


a: Anterior Chamber depth
c: Width of lens
x: Axial length (Length of the eye)
r_1: Radius of Cornea
r_2: Radius of Lens front surface
r_3: Radius of Lens back surface
n_1: Refractive Index (air)
n_2: Refractive Index of Aqueous
n_3: Refractive Index of Lens
n_4: Refractive Index of Vitreous

Dimensions	$[mm]$
Anterior Chamber (a)	3.6
Lens Width (c)	3.6
Axial Length (x)	24.17
Radii	$[mm]$
Cornea (r_1)	7.8
Anterior Lens (r_2)	10.0
Posterior Lens (r_3)	-6.0
Cornea (r_4)	7.8
Anterior Lens (r_5)	10.0
Posterior Lens (r_6)	-6.0
Refractive Indices	n
Aqueous humour (n_2)	1.336
Lens (n_3)	1.413
Vitreous (n_4)	1.413

2.15.3 Gullstrand's Exact Schematic Eye

Gullstrand's Exact Schematic Eye is the most complex eye model and assumes six refracting surface (see On every trial, the observer first saw a target shape for 400ms, followed by a 400ms fixation interval. After the fixation interval, $n \in \{2, 4, 8\}$ shapes were presented for a duration controlled by an adaptive staircase procedure. When the presentation interval was over, the shapes were immediately followed by a mask that consisted of n superimposed shapes from the set of distractors (all distractor shapes from the current trial plus one additional random shape on target trials). The mask remained visible until the observer pressed a button to indicate if they saw a target or not.On every trial, the observer first saw a target shape for 400ms, followed by a 400ms fixation interval. After the fixation interval, $n \in \{2, 4, 8\}$ shapes were presented for a duration controlled by an adaptive staircase procedure. When the presentation interval was over, the shapes were immediately followed by a mask that consisted of n superimposed shapes from the set of distractors (all distractor shapes from the current trial plus one additional random shape on target trials). The mask remained visible until the observer pressed a button to indicate if they saw a target below).



a: Anterior Chamber depth
b: Width of Cornea
f: Lens Cortex anterior
i: Lens Nucleus (inner lens) width
t: Lens Cortex postrior v: Width of Vitreous
x: Axial length (Length of the eye)
r_1: Radius of Cornea front surface
r_2: Radius of Cornea back surface
r_3: Radius of Lens Cortex anterior
r_4: Radius of Lens Nucleus anterior
r_5: Radius of Lens Nucleus posterior
r_6: Radius of Lens Cortex posterior
n_1: Refractive Index (air)
n_2: Refractive Index of Cornea
n_3: Refractive Index of Aqueous humour
n_4: Refractive Index of Lens Cortex
n_5: Refractive Index of Lens Nucleus
n_5: Refractive Index of Vitreous

Dimensions	$[mm]$
Width of Cornea (b)	0.5
Anterior Chamber (a)	3.1
Lens Cortex anterior (f)	0.546
Lens Nucleus (i)	2.419
Lens Cortex posterior (t)	0.635
Vitreous (v)	17.185
Axial Length (x)	24.385
Radii	$[mm]$
Cornea anterior (r_1)	7.7
Cornea posterior (r_2)	6.8
Lens Cortex anterior (r_3)	10.0
Lens Nucleus anterior (r_4)	7.911
Lens Nucleus posterior (r_5)	-5,76
Lens Cortex posterior (r_6)	-6.0
Refractive Indices	n
Cornea (n_2)	1.376
Aqueous humour (n_3)	1.336
Lens Cortex (n_4)	1.386
Lens Nucleus (n_5)	1.406
Vitreous (n_6)	1.336

2.16 Retinal Blur Circle

Focus in front of the Retina

$$BC = p \cdot \frac{x - f'_e}{f'_e}$$

BC: Blur Circle
p: Pupil Diamter
x: Axial Length
f'_e: Focal length of eye

Focus behind the Retina

$$BC = p \cdot \frac{f'_e - x}{f'_e}$$

or

$$BC = \frac{K}{K'}$$

where $K = {}^1/_x - {}^1/_{f'_e}$ and $K' = {}^1/_x$.

2.17 Spectable Magnification

$$SM = \frac{h'_c}{h'_u}$$

SM: Spectacle Magnification
h'_c: Corrected Image Size
h'_e: Uncorrected Image Size

For thin lens:

$$SM = \frac{1}{1 - (d \cdot F_{sp})}$$

d: Vertex Distance
F_{sp}: Spectacle Lens Power

Relative Spectacle Magnification

$$RSM = \frac{K}{F_{sp}} \cdot \frac{K'_{EM}}{K'}$$

K: Ocular Refraction
F_{sp}: Spectacle Lens Power
K'_{EM}: Dioptric Length of emmetropic eye
K': Dioptric Length of ametropic eye

Chapter 3

Visual Pereception

3.1 Contrast

3.1.1 Weber Contrast

$$C_{Weber} = \frac{L - L_b}{L_b}$$

L: Luminance of target
L_b: Luminance of background

3.1.2 Michelson Contrast

$$C_{Michelson} = \frac{L_{max} - L_{min}}{L_{max} + L_{min}}$$

L_{max}: Maximum luminance
L_{min}: Minimum luminance

3.1.3 Root Mean Square (RMS) Contrast

$$C_{RMS} = \left[\frac{1}{n-1} \sum_{i=1}^{n} \left(x_i - \bar{x} \right)^2 \right]^{0.5}$$

where x_i is a normalized grey-level value such that $0 \leq x_i \leq 1$ and $\bar{x}$ is the mean normalized gray level:

$$\bar{x} = \frac{1}{n} \sum_{i=1}^{n} x_i$$

3.2 Sensation & Perception

3.2.1 Weber's Law

$$\frac{\Delta I}{I} = k$$

ΔI: Just Noticable Difference
I: Stimulus intensity
k: Weber fraction

3.2.2 Fechner's Law

$$p = k \ln \frac{S}{S_0}$$

p: Just Noticable Difference
I: Stimulus intensity
k: Weber fraction

3.2.3 Steven's Power Law

3.2.4 Ricco's Law

3.2.5 Bloch's Law

Chapter 4

Anatomy

Chapter 5

Binocular Vision

Chapter 6

Orthoptics

- Difference between eso/exo/hypo/hyper
- Difference between phoria and tropia
- Which muscles were responsible for adduction, abduction, incyclo, excyclo etc
- Directions of maximal action for each EOM
- Hering's Law
- Sherrington's Law
- heard's Criterion
- Which EOMs were innervated by which cranial nerves
- Difference between cover-uncover and alternate cover test
- The different types of alphabet patterns and the EOMs they were associated with

- Difference between underaction and restriction
- Hess Chart interpretation
- Difference between concomitance and incomitance
- Order of muscle sequelae
- Which order to assess motor fusion in (Base In first, then Base Out, etc)
- Which direction the prism needs to go in order to induce or correct a deviation (BI to correct exo or induce eso, BO to correct eso or induce exo)
- Difference between crossed and uncrossed diplopia
- Which side to tilt to and which eye to look at on the Bielschowsky Head Tilt Test