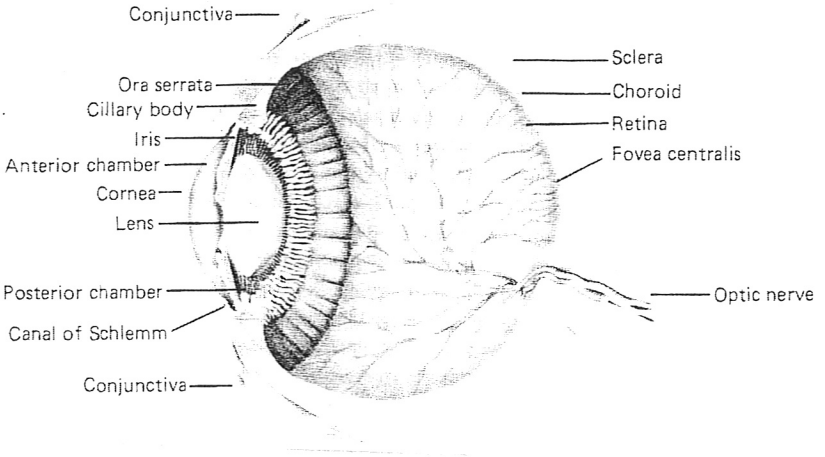
Human Eye



Almost spherical shape
23 mm diameter

Aqueous humor $n = 1.336$
Iris
crystalline lens : adjustable focus

Relaxed : lens is flattest
smallest focal length
Focused on distant objects

Tensed : lens bulges
more curved
focused at near objects

lens refractive index graded 1.39 → 1.41

Vitreous humor : $n = 1.336$

rods : BW
cones : color

on retina
curved image plane

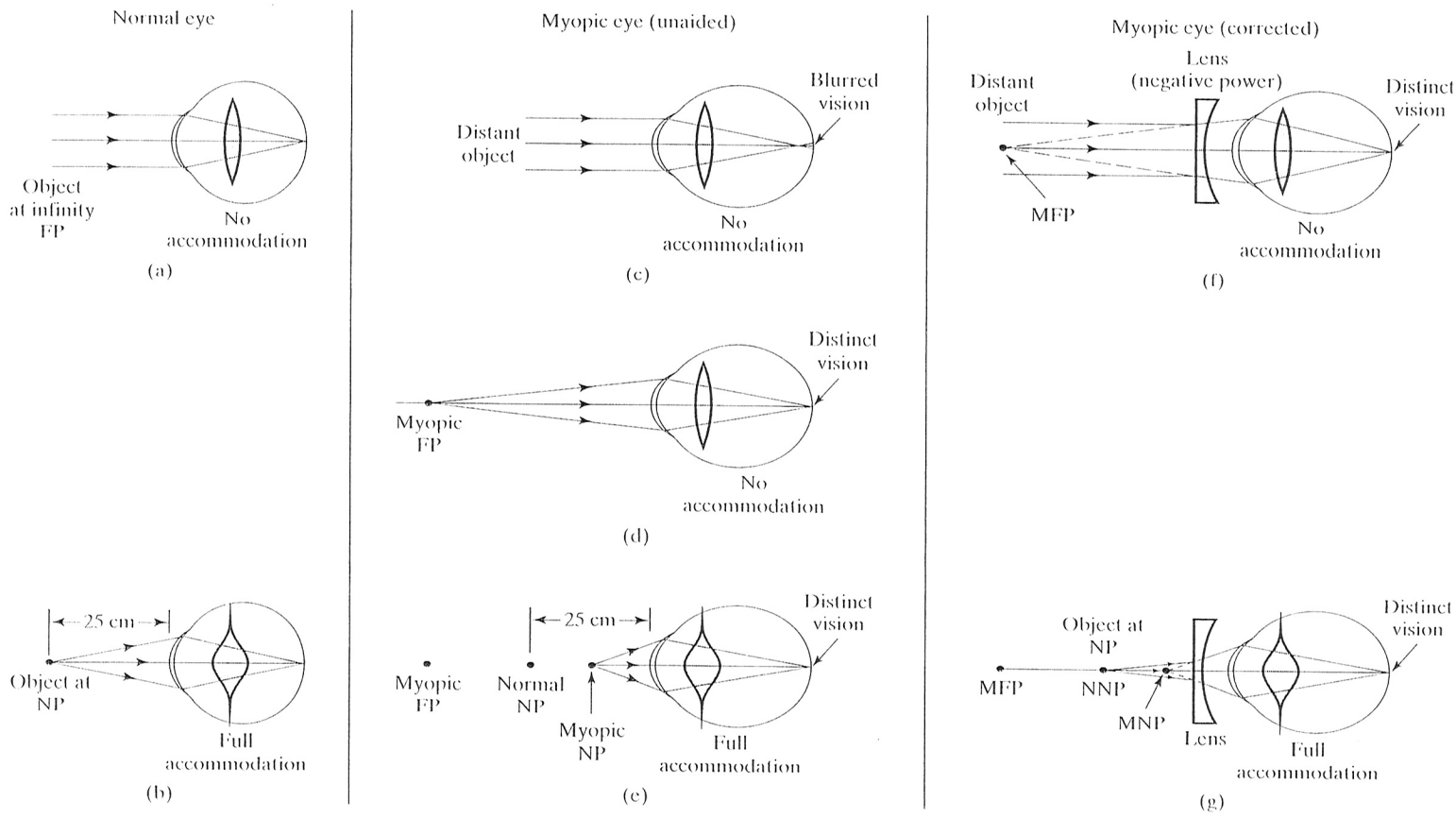


Figure 10-7 A comparison of normal and myopic vision, with optical correction. Note that refraction by the eye lens is not shown. The abbreviations read as follows: MFP = myopic far point; NNP = normal near point; MNP = myopic near point.

Optical models of the eye

Helmhotz - Laurence Schematic eye

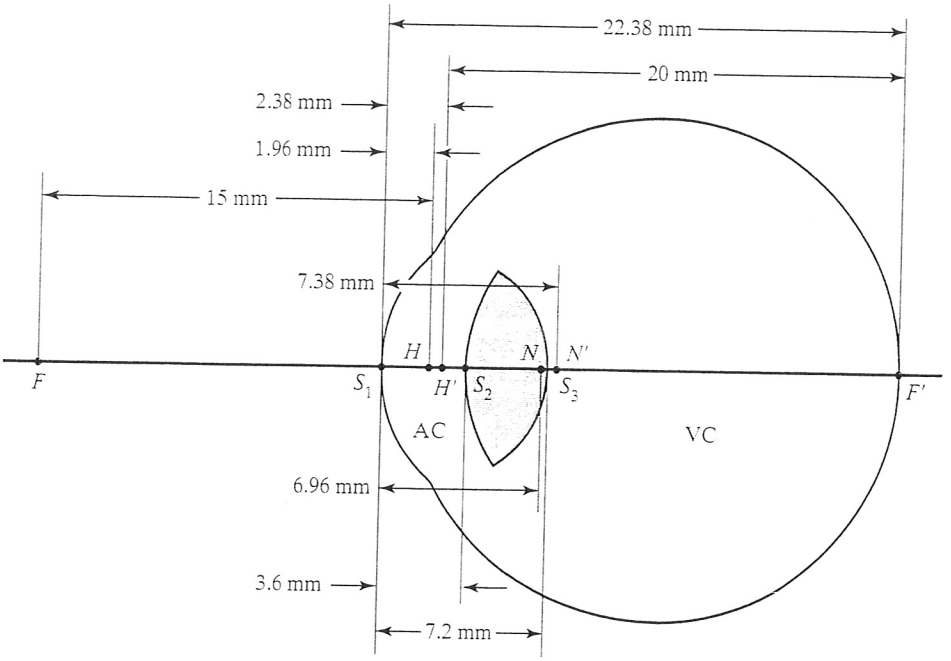


Figure 10-3 Representation of H. V. Helmholtz's schematic eye 1 as modified by L. Laurance. For definition of symbols, refer to Table 10-1. (Adapted with permission from Mathew Alpern, "The Eyes and Vision," Section 12 in *Handbook of Optics*, New York: McGraw Hill, 1978.)

TABLE 10-1 CONSTANTS OF A SCHEMATIC EYE (HELMHOLTZ-LAURANCE)

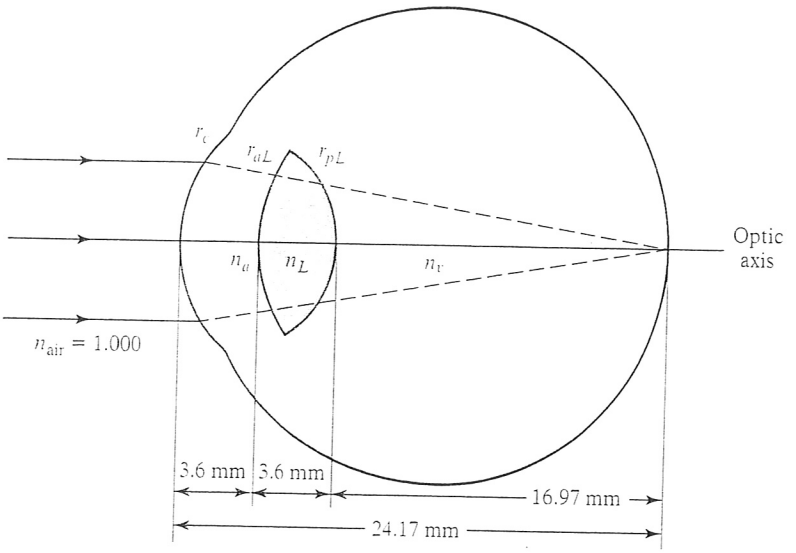
Optical surface or element	Defining symbol	Distance from corneal vertex (mm)	Radius of curvature of surface (mm)	Refractive index	Refractive power (diopters)
Cornea	S_1	—	+8[a]	—	+41.6
Lens (unit)	L	—	—	1.45	+30.5
Front surface	S_2	+3.6	+10[b]	—	+12.3
Back surface	S_3	+7.2	−6	—	+20.5
Eye (unit)	—	—	—	—	+66.6
Front focal plane	F	−13.04	—	—	—
Back focal plane	F'	+22.38	—	—	—
Front principal plane	H	+1.96	—	—	—
Back principal plane	H'	+2.38	—	—	—
Front nodal plane	N	+6.96	—	—	—
Back nodal plane	N'	+7.38	—	—	—
Anterior chamber	AC	—	—	1.333	—
Vitreous chamber	VC	—	—	1.333	—
Entrance pupil	E_nP	+3.04	—	—	—
Exit pupil	E_xP	+3.72	—	—	—

Source: Adapted with permission from Mathew Alpern, "The Eyes and Vision," Table 1, Section 12 in *Handbook of Optics*, New York: McGraw-Hill Book Company, 1978.

[a]In this model, the cornea is assumed to be infinitely thin. In Gullstrand's exact schematic eye, for example, the cornea is retained as a two-surface element of 0.5 mm thickness.

[b]Value given is for the relaxed eye. For the tensed or fully accommodated eye, the radius of curvature of the front surface is changed to +6 mm.

Gull strand 3-surface simplified Schematic eye



r_c = corneal radius = 7.8 mm
r_{aL} = anterior lens surface = 10 mm
r_{pL} = posterior lens surface = −6 mm
n_a = aqueous humor index = 1.336
n_L = average lens index = 1.413
n_v = vitreous humor index = 1.336

Emsley Standard Reduced 60D Eye

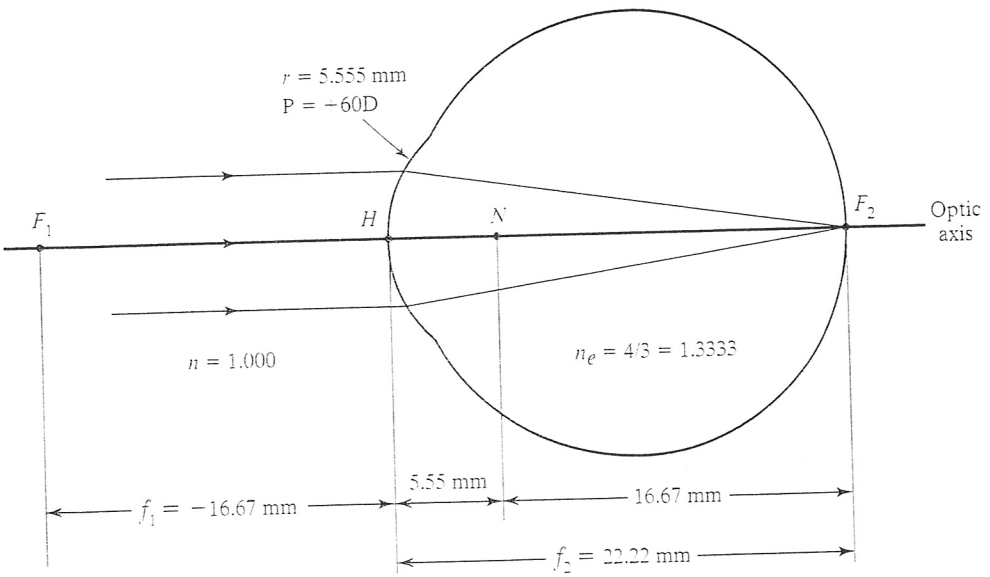


Figure 10-5 Emsley's standard reduced 60-diopter eye. Note that the model of this eye is represented by a single curved surface, where the two principal points H and H' and two nodal points N and N' (shown in Figure 10-3) coalesce into single points H and N, respectively. The focal points F_1 and F_2 are measured relative to the principal point H. Here the axial length of the emmetropic eye, from cornea to retina, is 22.22 mm, thereby ensuring that parallel rays for this model focus on the macula at the retinal surface.

Treat as single perfect lens with power K=60D
image distance of relaxed eye

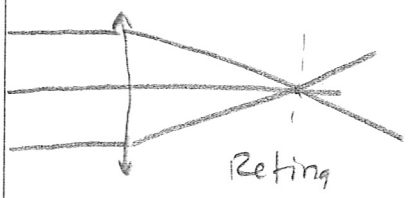
$$\frac{1}{S_o} - \frac{1}{S_i} = \frac{1}{f} = K$$

$$\frac{1}{\infty} + \frac{1}{S_i} = 60$$

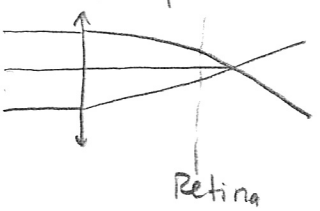
$$S_i = \frac{1}{60} = 16.67\text{mm}$$

Vision correction

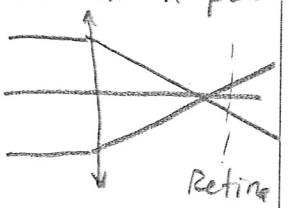
Normal Eye
(Emmetropic)



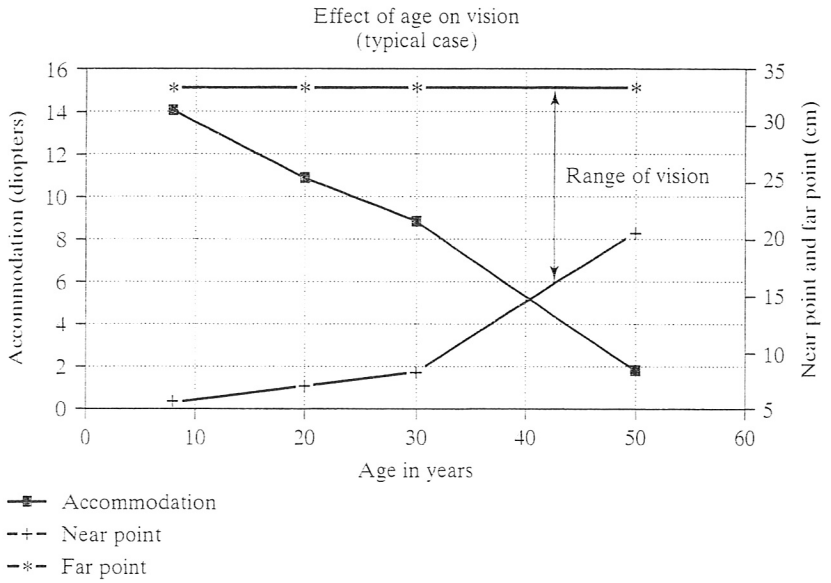
Far Sighted
(Hyperopic)
too little power



Near Sighted
(Myopic)
too much power



Accomodation: Range of lens power change
controls far point - near point distance



For corrected eye $P = 60D$, $S_i = 16.67\text{mm}$

Age 10: $P = 60 + 14 = 74\ D$

$$\frac{1}{S_o} + \frac{1}{0.01667} = 74 \qquad S_o = 71.4\text{mm}$$

$\infty < S_o < 71\text{ mm}$
$\infty < S_o < 3''$

Age 50 $P = 60 + 2 = 62$

$$\frac{1}{S_o} + \frac{1}{0.01667} = 62 \qquad S_o = 500\text{mm}$$

$\infty < S_o < 500\text{mm}$
$\infty < S_o < 20''$

Far Sighted Example : P = 55 D Find NP and FP
Accomodation 8D

$\frac{1}{S_o} + 60 = 55$

$S_o = (55 - 60)^{-1} = -0.2$

$FP = \infty$

$\frac{1}{S_o} + 60 = (55 + 8)$

$S_o = 0.33\ m$

$\infty < S_o = 0.33\ m$

Near Sighted P = 65
Accomodation 8D

$\frac{1}{S_o} + 60 = 65 =$

$S_o = 0.2\ m$

$\frac{1}{S_o} + 60 = 65 + 8$

$S_o = 0.077\ m$ $0.2\ m < S_o < 0.077\ m$