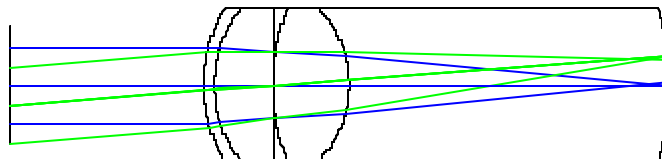


Schematic Eyes - Introduction

- Curvatures, spacings and indices of the ocular components lead us to raytracing the surfaces to determine the imaging properties of the eye.
- Many schematic eye models exist of varying complexity.
- Cardinal points are a first priority, aberration analysis is a more sophisticated analysis.

Gullstrand-LeGrand Eye Model

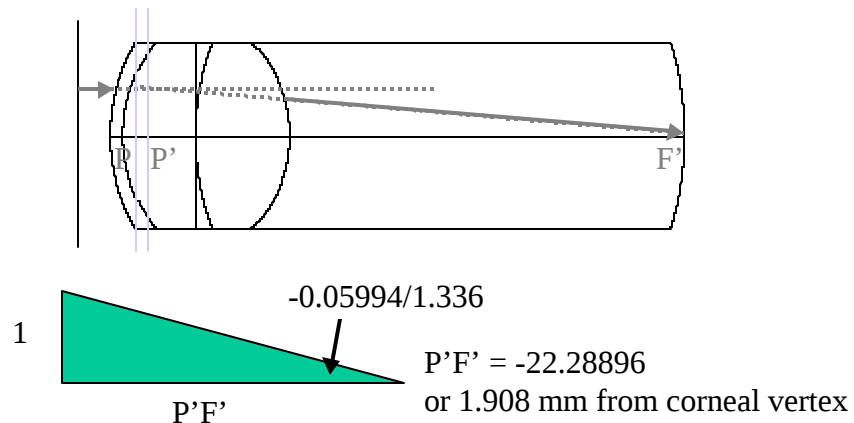
		Anterior Cornea		Posterior Cornea		Anterior Lens		Posterior Lens		Retina
R (mm)		7.8		6.5		10.2		-6		-13.4
-f (mm ⁻¹)		-0.04835		0.006108		-0.0081		-0.014		
t (mm)	Infinity		0.55		3.05		4		16.59655	
n	1		1.3771		1.3374		1.42		1.336	
t/n (mm)			0.39939		2.280544		2.816901		12.42257	
y (mm)		1		0.980691		0.884095		0.744614		0
nu (rad)	0		-0.04835		-0.04236		-0.04952		-0.05994	
yc (mm)		-0.30376		-0.25796		0		0.31862		1.668325
nuc (rad)	0.1		0.114686		0.11311		0.11311		0.108649	



Cardinal Points & Pupils

- Principal Planes – conjugate planes that have unit magnification. Can be used to generate effective lens.
- Focal Points – points where collimated beams come to focus.
- Nodal Points – a ray passing through the front nodal point at a given angle, leaves the rear nodal point at the same angle.
- Entrance and Exit pupils – conjugate planes that are the entrance and exit ports of the optical system.

Principal Planes



Similarly, the front principal plane P is located 1.595 mm from corneal vertex.

Total Power

Total Power $\Phi = n' / P'F'$

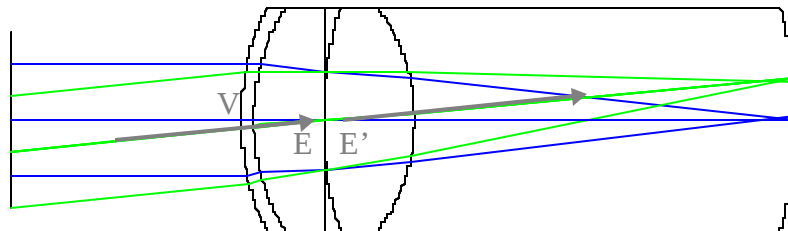
$$\Phi = 1.336 / 22.28896 \text{ mm} = 0.05994 \text{ mm}^{-1} = 59.94 \text{ D}$$

Total Power $\Phi = 1 / PF$

$$PF = -16.683 \text{ mm}$$

or the front focal point is -15.089 mm from corneal vertex
(about where your spectacles sit).

Pupils



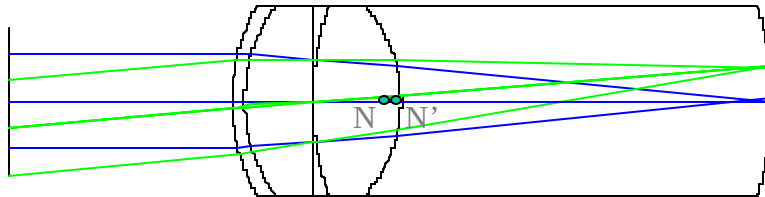
Exit Pupil
0.108049/1.336
0.31862
VE' = 3.682 mm

Nodal Points

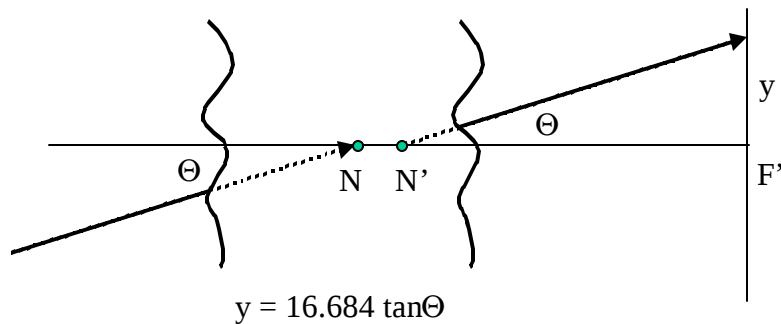
$$PN = P'N' = (n_{\text{vit}} - n_{\text{air}}) / \Phi = 0.336 / 0.05994 = 5.605 \text{ mm}$$

Front Nodal Point N is 7.200 mm from corneal vertex

Rear Nodal Point N' is 7.513 mm from corneal vertex

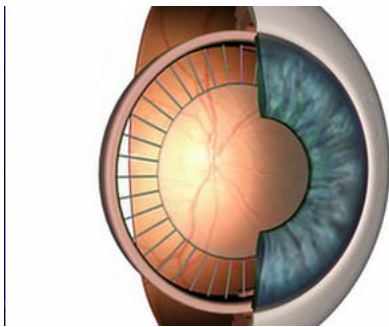


Angular Subtense

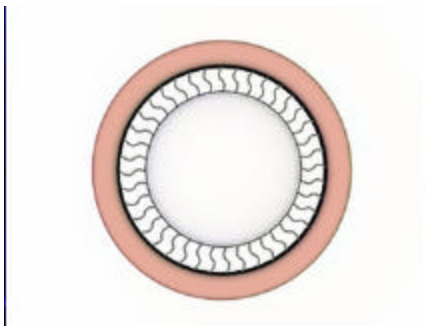


Typically, 1 minute of arc is stated as the eye's limit of resolution. This leads to $y \sim 5$ microns (two points separated by 5 microns on the retina can just be resolved).

Accommodation



Relaxed ciliary muscle
pulls zonules taut and
flattens crystalline lens.



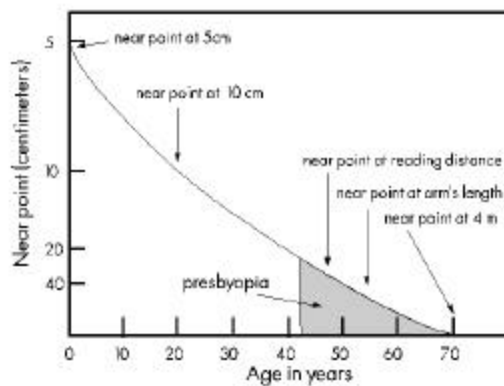
Constrict ciliary muscle
releases tension on
zonules and crystalline
lens bulges.



Accommodated Gullstrand Model

	R (mm)	n	t' (mm)
Anterior Cornea	7.8	1.3771	.55
Posterior Cornea	6.5	1.3374	2.65
Anterior Lens	6.0	1.4270	4.50
Posterior Lens	-5.5	1.3360	16.497

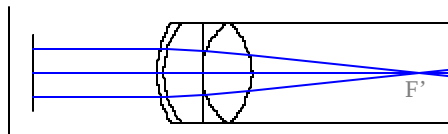
Presbyopia



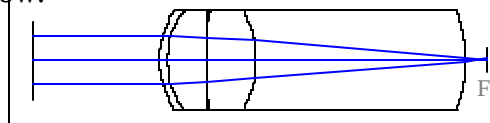
Your ability to accommodate reduces steadily with age. Typically, you don't notice the effects until it affects your ability to read comfortably. This is presbyopia.

Definitions – Refractive Error

- Myopia – near-sightedness. F' is in front of retina because eye is too long or power is too high



- Hyperopia – far-sightedness. F' is behind retina because eye is too short or power is too low.

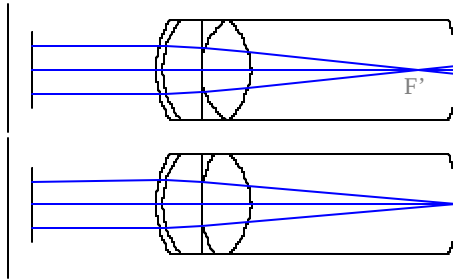


- Emmetropia – perfect vision. F' at retina.

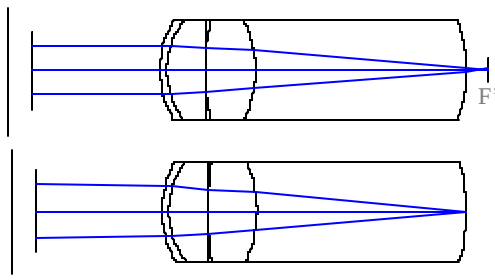
Definitions

- Far Point – point conjugate to the retina when eye is unaccommodated.

Myopia



Hyperopia



- Near point – point conjugate to the retina when the eye is fully accommodated.