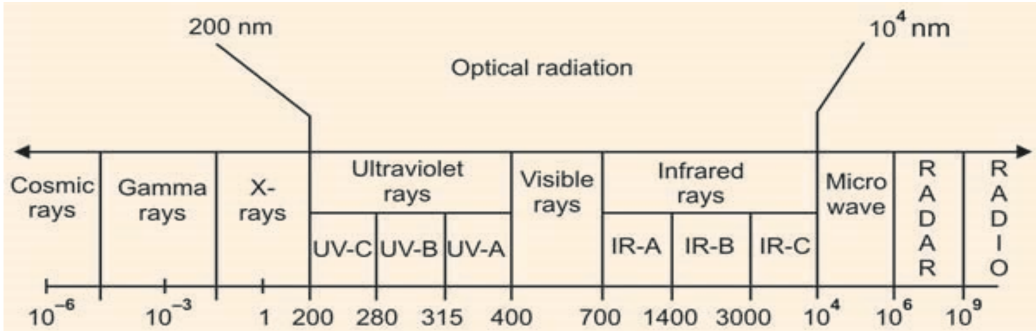
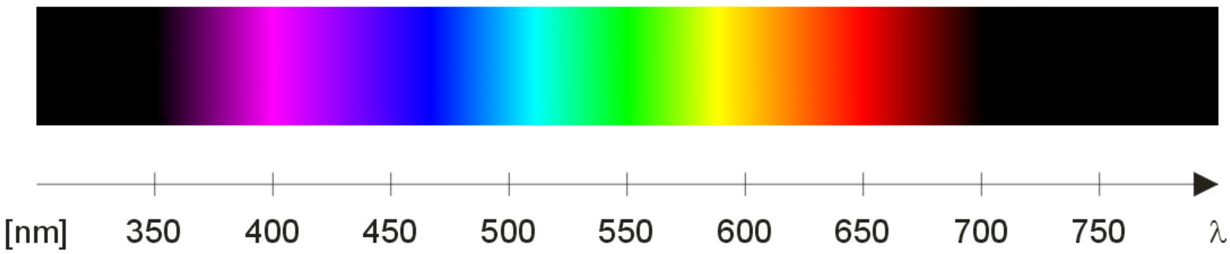


Fig. 7-1: Electromagnetic spectrum [wavelength (λ) in nm]



The energy of the individual photons of the electromagnetic spectrum is inversely related to it's wavelength. Thus, the shorter the wavelength, the greater the energy of the individual photons of optical radiation. Ultraviolet rays and infrared rays are responsible for certain radiational damage to ocular tissues.

ULTRAVIOLET RAYS (UV RAYS)

UV light is invisible and sunlight is the principal source of UV light. UV light is further subdivided depending on their absorption spectrum into 3 bands (Figs 7-1 and 13-4);

1- UV–C (200–280 nm)— This band of UV rays from sunlight is blocked by the ozone layer (O3) of the earth's atmosphere. However, the ozone layer is less thick at high altitudes and near the equator. Hence, the amount of absorption of UV–C rays by atmosphere varies.

2- UV–B (280–315 nm)—This band of UV rays is blocked by the corneal epithelium. UV–B is responsible for snow blindness from reflected sunlight and corneal burn (photokeratitis) from arc welding. Cornea is also susceptible to prolonged UV–B radiation resulting in pinguecula and pterygium.

3- UV–A (315–400 nm)—Retinal photoreceptors are sensitive to UV rays between 350–400 nm. However, this band of UV rays (UV–A) is absorbed by the crystalline lens (315–380 nm). Hence, the retina is protected against UV rays radiation. Prolonged exposure to low dose of this radiation can cause cataract. So, in aphakia and pseudoaphakia eyes (IOL without UV filter) experience a sensation of blue or violet colours. Thus, intraocular lens implants are suitably impregnated with UV–A inhibitor called "chromophores" to protect the retina.

VISIBLE RAYS

It is actually composed of seven colours of specific wavelengths. The red colour is on the longer wavelength side and violet is on the shorter wavelength end. In photopic conditions (bright light) the retina is maximally sensitive to 555 nm (yellow–green) wavelength, whereas in scotopic conditions (dim light) it is sensitive to 510 nm (blue) wavelength.

INFRARED RAYS

Infrared rays are also invisible and are further subdivided into three bands, depending on their absorption spectrum (Fig. 7-1);

1- IR–A (700–1400 nm)—Excess exposure to these IR rays may cause eclipse blindness and cataract.

2. IR–B (1400–3000 nm)—Excess exposure to these IR rays may cause corneal opacity and cataract.

3- IR–C (3000–104 nm)—Excess exposure to these IR rays may cause corneal opacity and cataract. Most of the infrared rays (Fig. 7-1) are absorbed in the anterior chamber of the eyes and cause a rise in temperature. Hence, they are also called heat rays. Cornea and sclera absorbs infrared rays of wavelength beyond 1400 nm (IR–B and IR–C). Hence visible rays (400–700 nm) and infrared rays of wavelengths between 700–1400 nm (IR–A) are partly transmitted to the retina (see Fig. 13-4 in chapter-13). Infrared rays absorption during solar eclipse cause photoretinitis, i.e. eclipse blindness.

Schematic eye

Schematic eyes are designed to simplify optics of the eyes to replace the complex optics of the human eye. Schematic eyes assumes:

The eye is homocentric, i.e. presence of a common optical axis.

The refracting surfaces are spherical.

The cornea and the lens form the optical refracting elements. Different types of schematic eyes are designed taking into account various parameters from a simple one to a complex one.

Gullstrand Schematic Eye No. 1

Gullstrand's schematic eye provides us with the numerical values for the radii of curvature, indices of refraction, distance between the refracting surfaces and location of the principal points, nodal points and focal points (Fig. 7-2). Gullstrand's schematic eye no. 1 has six refracting surfaces and this eye has a refractive error of +1D possibly to neutralise the relative myopia produced by spherical aberrations through peripheral areas of pupil. The accommodation exerted in accommodative state is 10.6D. Gullstrand described schematic eye in both unaccommodated and maximally accommodated state, with a change in variables involving the lens only. • In this eye, power of the cornea is +43.00D and power of the lens is +19.11D.

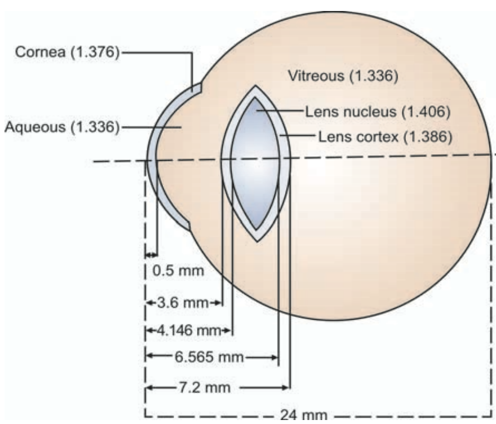


Fig. 7-2: Gullstrand's schematic eye no. 1 showing numerical values of various parameters

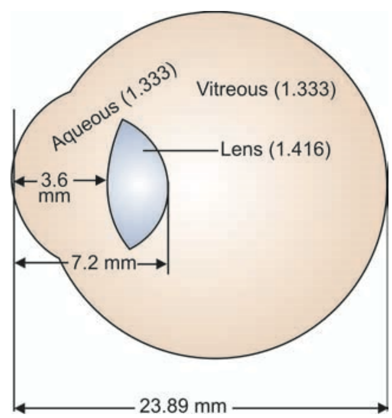


Fig. 7-3: Gullstrand–Emsley schematic eye

Gullstrand–Emsley Schematic Eye

Emsley developed this schematic eye with the following modifications (Fig. 7-3) of the Gullstrand's schematic eye no. 1: The lens is made optically homogeneous, i.e. the central nuclear area having different refractive index is abolished

The posterior corneal surface is also removed. So, no. of refracting surfaces is reduced to 3 from earlier 6 surfaces. The refractive index of aqueous humour and vitreous houmour is changed from 1.336 to 1.333. The Gullstrand–Emsley schematic eye is emmetropic, as opposed to the Gullstrand schematic eye no. 1 which is +1.00D hypermetropic.

Donder's Reduced Eye

"Reduced Eye" is constructed by Donder with the following modifications (Fig. 7-4) of the schematic eyes. It has only one refracting surface, i.e. the cornea with the elimination of the lens. It's total dioptric strength is +58.6D and refractive index is 1.336. It is emmetropic with the second focal length, i.e. axial length of 24.13 mm. The second focal point is on the retina. The first focal point is –15.7 mm in front of the cornea. Radius of curvature of the cornea is 5.73 mm, as opposed to 7.7 mm in a schematic eye. Since there is only one refracting surface, the first and second principal planes, points and nodal points merge to form only one principal plane, principal point and nodal point (Fig. 7-4).

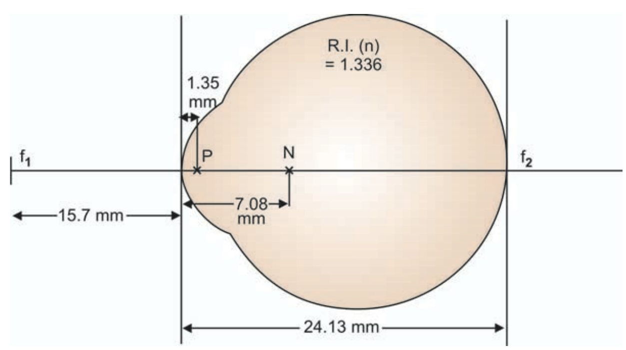
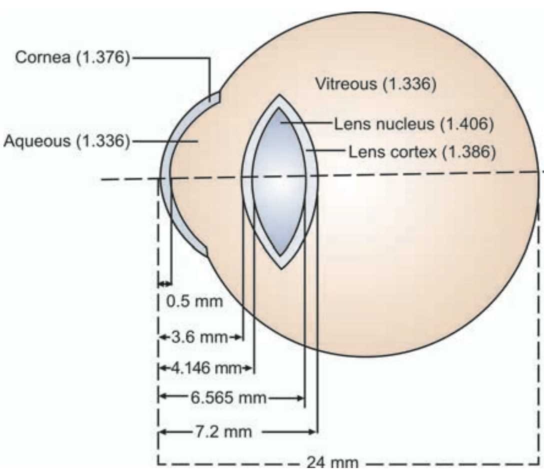


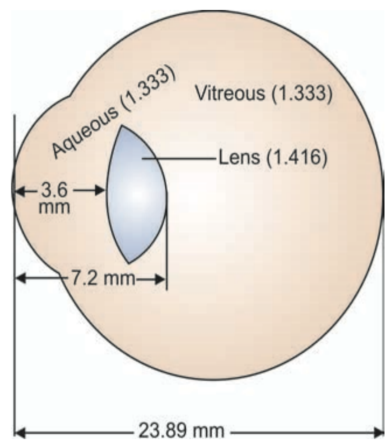
Fig. 7-4: Donder's reduced eye. P = Principal point; N = Nodal point; f_1 = First focal point; f_2 = Second focal point

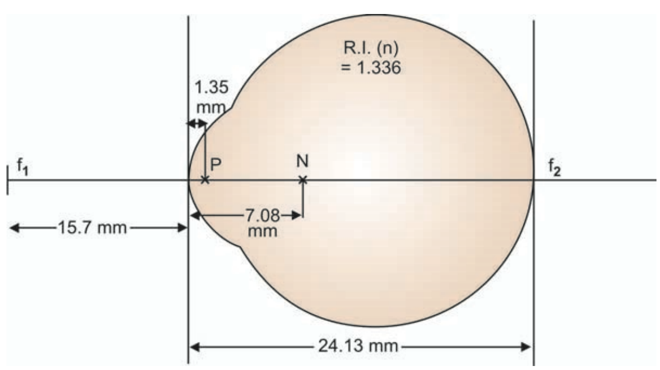
The principal point is 1.35 mm behind the anterior corneal surface and the nodal point is 7.08 mm behind the anterior corneal surface (Fig. 7-4).

Emsley also constructed "reduced eye" with the numerical values of various parameters as follow:

- Refractive index = 1.333 • Dioptric strength = +60.00D
- First focal point (f1) = – 16.67 mm in front of the cornea
- Second focal point (f2) = + 22.22 mm behind the cornea
- Axial length of this reduced eye = +22.22 mm
- Radius of curvature of cornea = 5.55 mm. Clinical Application of Reduced Eye
- Calculation of retinal image size
- Designing of ophthalmic instruments
- Calculation of intraocular lens (IOL) power.







Draw and compare between the schematic diagrams of eye as Gullstrang, Emsley and Donder models?

AXES AND ANGLES OF THE EYE

The pupil is slightly decentred, the lens is tilted and the fovea is not aligned with the optic axis. Hence, the eyeball is not a perfectly centred one, the radius of curvatures of different refractive surfaces of the eye do not fall on a common optic axis.

AXES

Optic Axis :It is the straight line which passes through centres of curvatures of different media of the eye, as close as possible (Fig. 7-5).

Pupillary Axis: It is the straight line which passes through the centre of the pupil.

Visual Axis It is the straight line which passes through the fovea and the nodal point (Fig. 7-5) of the eye.

Fixation Axis: It is the line joining the fixation point with the centre of rotation of the eyeball (Fig. 7-5).

ANGLES

Angle Alpha (α): It is the angle formed between the optic axis and the visual axis (Fig. 7-5).

Angle Kappa (κ): It is the angle formed between the pupillary axis and the visual axis (Fig. 7-5).

Angle Gamma (γ): It is the angle formed between the optic axis and the fixation axis (Fig. 7-5).

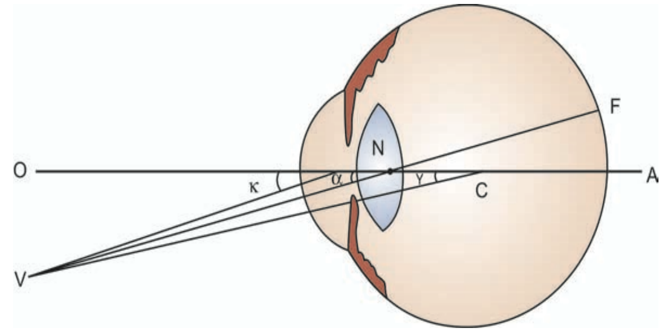


Fig. 7-5: Axes and angles of the eye. OA = Optic axis; α = Angle alpha; VF = Visual axis; κ = Angle kappa; VC = Fixation axis; γ = Angle gamma and N = Nodal point