A model eye

The vertebrate eye has a single surface water lens that brings light to an approximate focus on a retina lining the back of a spherical cavity. Like all optical instruments (telescopes and cameras) the inside of the cavity is black to reduce fogging of the image by unwanted multiple reflections. The internal lens changes shape to bring objects at a given distance into focus. Light levels are controlled by pupil dilation. The sensitivity of the human eye is further enhanced in low light by slow adaptation of the retina that increases in sensitivity over an hour or so.

The main points of the optics of the eye can be modeled as follows.

Fig 1 – a clear condom, ping-pong balls (black and white), cutters, sandpaper and thread.

Select a clear latex condom and tie off a spherical water balloon a little larger in volume than a ping-pong ball. If black ones cannot be found, paint white ones black.

Fig 2 – a transparent water balloon.

Remove two circular pieces on opposite sides of a black ball and smooth the edges with sandpaper.

Fig 3 – the prepared outer shell and retinal implant.

Cut a disc from a white ball to serve as a translucent back to the eye. Insert the white section into the black ball and put in a filled water balloon as shown. The water balloon protrudes out of the larger circular hole to form a model cornea.

Fig 4 – the single surface water lens (cornea) in place.

Construction

It is possible to get a water balloon tied off to the right size to fit in the black ball with an appropriate corneal curvature. Alternatively, the balloon can be inflated with water when inside the ball with a syringe and a short section of small diameter hose, tied into the balloon and inserted through a hole in the black outer shell.

The image of distant windows is inverted in the back of the eye as expected but is initially blurred because of the large aperture and the lack of adjustment to the radius of curvature of the cornea.

Fig 5 – the image of windows is blurred.

Adding a correcting lens (a monocle) improves the focus, as does reducing the aperture with a lens stop.

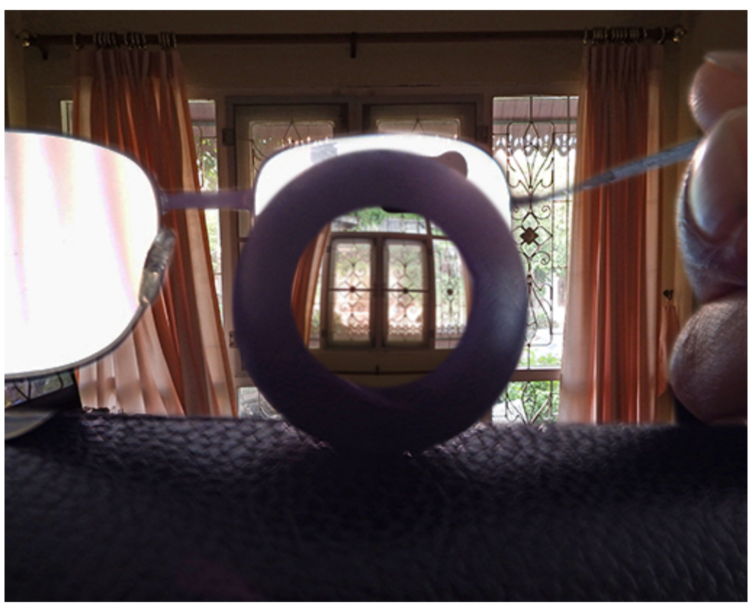

Fig 6 – much improved focus with a lens in front of the cornea.

Astigmatism

By varying the size of the corneal hole and the filling of the water balloon to alter the curvature of the water lens, short sight and long sight can be modeled. Adding an external pupil lowers the intensity of the image and improves definition.

If the sides of the eye are squeezed the opening in the ball becomes oval and the corneal lens takes on different radii of curvature in perpendicular directions. The image in the back of the eye is degraded by astigmatism. The focus is better in one direction than the other which can be seen by using parallel lines as objects. Suitable lenses for correction can be found or made, by for instance, casting gelatin lenses in spoons.

Alternatively, an eye model can be made with an astigmatic lens in the relaxed position by cutting an oval corneal hole.

> **Note:** *eyes should be made when required. The transparent latex rubber becomes cloudy if exposed to air overnight.*

Questions

1 Determine the radius of curvature of the cornea and the desired focal distance to a small flat screen in contact with the flat surface on the back of the model eye with a ruler to the nearest mm on the diagram below.

2 Use the "lens makers formula" to find the focal point of light from a distant object. Find an approximate correction needed for clear focus for distant vision in diopters, by treating the cornea and a correcting contact lens as thin lenses.

3 Find an approximate correction for reading fine print at 10 cm in dipotres.