The Eye

You have probably become familiar by now with the architecture of the human eye in the lecture section. You will remember that the human eye is an optical system with four main components: the **cornea**, the **iris**, the **crystalline lens**, and the **retina**. The cornea and the crystalline lens work together to produce a sharp real image on the retina, while the iris serves as an adjustable aperture, regulating the amount of light which is reaches the retina. The retina is composed of a network of light-sensitive cells which are connected to the optic nerve. The point where the optic nerve connects to the retina is called the blind spot, because there are no light-sensing cells there. While the cornea and crystalline lens both function as lenses, the crystalline lens is flexible, allowing the focal length of the crystalline lens to be altered so that the eye can focus on objects at various distances.

While the human eye is a remarkable optical instrument, it is not perfect. Three of the most common problems which occur in human eyesight are **myopia**, **hypermetropia**, and **astigmatism.** Myopia and hypermetropia are commonly known as near- and far-sightedness, respectively. They are usually caused by a genetic elongation or shortening of the eye itself. If the eye is elongated, then the normal focal point will fall short of the retina, and objects at a distance will not be focused. This is the cause of myopia. If the eye is shorter than normal, objects at a distance can be focused, but objects up close will be out of focus. This is the cause of hypermetropia. Myopia is corrected by placing a divergent lens in front of the eye while hypermetropia is corrected by placing a converging lens in front of the eye. Astigmatism, unlike the other two problems, is caused by a deformation of the cornea. Normally, the cornea is in the shape of a **spherical lens**, that is, a lens with spherical symmetry. This symmetry means that an object will look the same no matter how you rotate it around the optical axis of the eye. Astigmatism is caused when the cornea is no longer spherically symmetric and begins to take on the shape of a cylindrical lens. If you have ever looked into the crazy mirrors in the fun-house, the ones which make you look very tall and thin or very short and fat, then you are familiar with the problem of astigmatism. Optically speaking, astigmatism means that horizontal lines are focused at a different point than vertical lines. Usually, astigmatism can be corrected through placing another cylindrical lens in front of the eye which compensates for the cylindrical deformation of the cornea.

In this laboratory, we will be utilizing a simple model of the eye to observe the problems of myopia, hypermetropia, and astigmatism.

Equipment:

The Eye Model consists of a water filled tank, a movable retina screen, and several slots in which various lenses and apertures can be placed. The following lenses are included with each model:

1. Spherical convergent (+ 7.00 D)
2. Spherical convergent (+ 20.00 D)
3. Spherical convergent (+ 2.00 D)
4. Spherical divergent (- 1.75 D)
5. Cylindrical divergent (- 5.50 D)
6. Cylindrical convergent (+ 1.75 D)

Additionally, a diaphragm is included to represent the iris of the eye. The following diagram illustrates the configuration of the eye model.

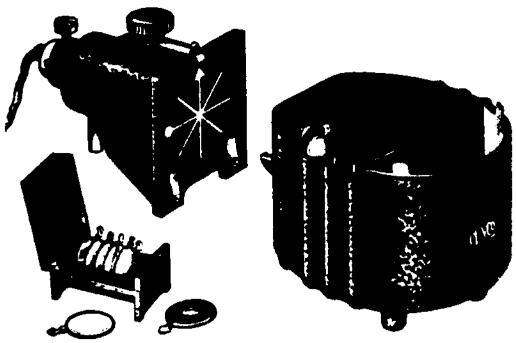

Fig. 1. Eye Model with Accessories

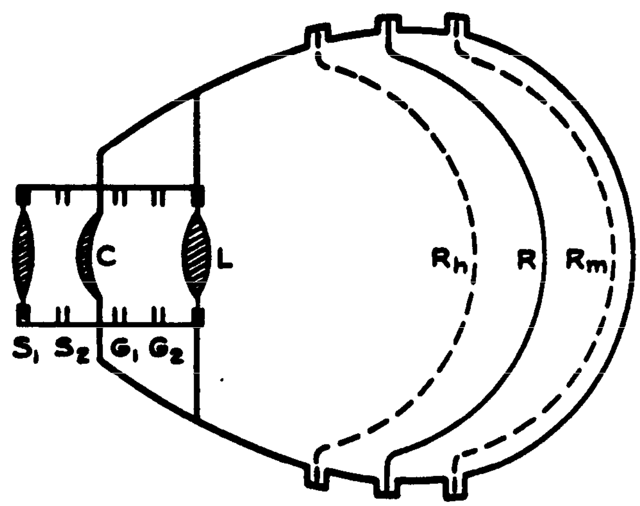

Fig. 2. Plan of Eye Model

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On the diagram, the position of the cornea is marked by C, the position of the changeable crystalline lens is marked by L, S1 and S2 represent positions for spectacle (corrective) lenses, and G1 and G2 represent positions for the diaphragm and the lens inside the eye. Rh represents the position of the retina to simulate hypermetropia, R represents the normal retinal position, and Rm represents the position of the retina to simulate myopia.

Procedure:

Fill the tank with water within about 2 cm of the top. Place the retina in the normal position and insert lens No. 1 in the septum.

In performing the following experiments, the student should report a full description of the procedure used. Since many of the observations involve the appearance of the image on the retina, this should be sketched on the data sheet and described. When quantitative measurements of the object and image distances are made, these should also be recorded.

A. Accommodation:

Face the eye toward a window or other large well illuminated object in the classroom and note the characteristic of the image on the retina. Determine the relative size of the image to that of the object. Place the illuminated object 35 cm in front of the eye and note the blurred appearance of the image. "Focus" the eye by replacing the crystalline lens No. 1 with lens No. 2.

B. Far-sightedness and Near-sightedness:

Keeping the object distance the same, move the retina to the forward position Rh, illustrating hypermetropia. Adjust the position of the object until the image is sharp. Select the proper spectacle lens from Nos. 3 and 4, mount it in front of the eye, and observe the effect on the image when the object is placed at the normal viewing distance of 35 cm. Replace the retina in the normal position and note the nature of the image. This illustrates what happens when a person with normal eyesight puts on the spectacles of a far-sighted person.

Remove the spectacle lens and shift the retina to the rear position Rm, producing myopia. Find the best viewing distance as before. Correct the myopia by applying the proper spectacle lens.

C. Pupil size:

With a normal or corrected eye, insert the diaphragm immediately before or behind the cornea and examine the image closely, noting the effect upon brightness and sharpness of the image. Explain.

D. Astigmatism:

With the retina in the normal position, insert the cylindrical lens No. 5 at G1 immediately behind the cornea with its axis vertical. With the object at normal viewing distance, observe the character of the image. Place the cylindrical lens No. 6 in front of the cornea and rotate it in the support until the image is most sharply defined. Note the direction of the axis of the spectacle lens. Repeat with the rear lens at a different angle.

Questions:

1. Approximately how must brighter is the image without the diaphragm in place then with it in place? Explain.

2. Is the focal length of a lens in water greater than the lens in air or less? Explain.

3. Would a given lens have the same focal length when placed at C as at L? Explain.

4. What harm, if any, would occur by rotating the spectacle lenses of a near-sighted person in their frames? What if the individual had an astigmatic correction?

Turn in your observations and the answers to these questions at the end of the lab period.

The Eye

Name:______________________Section:_________

Observations:

A: Accommodation
Sketch the shape of the object and the shape of the focused image on the retina.

B. Far-sightedness and Near-sightedness
What happened when you moved the retina to the point Rh?

Which spectacle lens corrected it?

Was this lens converging or diverging?

What happened when you moved the retina to the point Rm?

Which spectacle lens corrected it?

Was this lens converging or diverging?

C. **Pupil size**
Note the effect of the diaphragm on image brightness and sharpness.

D. Astigmatism

Sketch the image with the cylindrical lens in place.

What did you find about the axes of the two cylindrical lenses when the correction was made?

Questions:

1. Approximately how must brighter is the image without the diaphragm in place then with it in place? Explain.

2. Is the focal length of a lens in water greater than the lens in air or less? Explain.

3. Would a given lens have the same focal length when placed at C as at L? Explain.

4. What harm, if any, would occur by rotating the spectacle lenses of a near-sighted person in their frames? What if the individual had an astigmatic correction?