Module 1

Illumination Engineering Basics

Lesson 3

Eye and Vision – I

Instructional Objectives

1. Identify similarity between eye and camera
2. List the nerve system responsible for adaptation of eye.
3. List factors responsible for visual acuity.
4. State the purpose of good lighting.
5. Define glare.
6. Define Purkinjee effect.

Introduction

As already mentioned eye acquires > 80% information acquired by human. We look at the structure and function of eye here. An Eye comprises of Iris, Focusing Lens and Retina. It Resembles – a Camera in general structure and action.

Table I shows the similarity between them.

Eye	Camera
Iris	Shutter
Lens	Lens
Retina	Film

Table I: Eye Vs Camera

Fig. 1 shows the structure of eye. As may be seen it consists of:

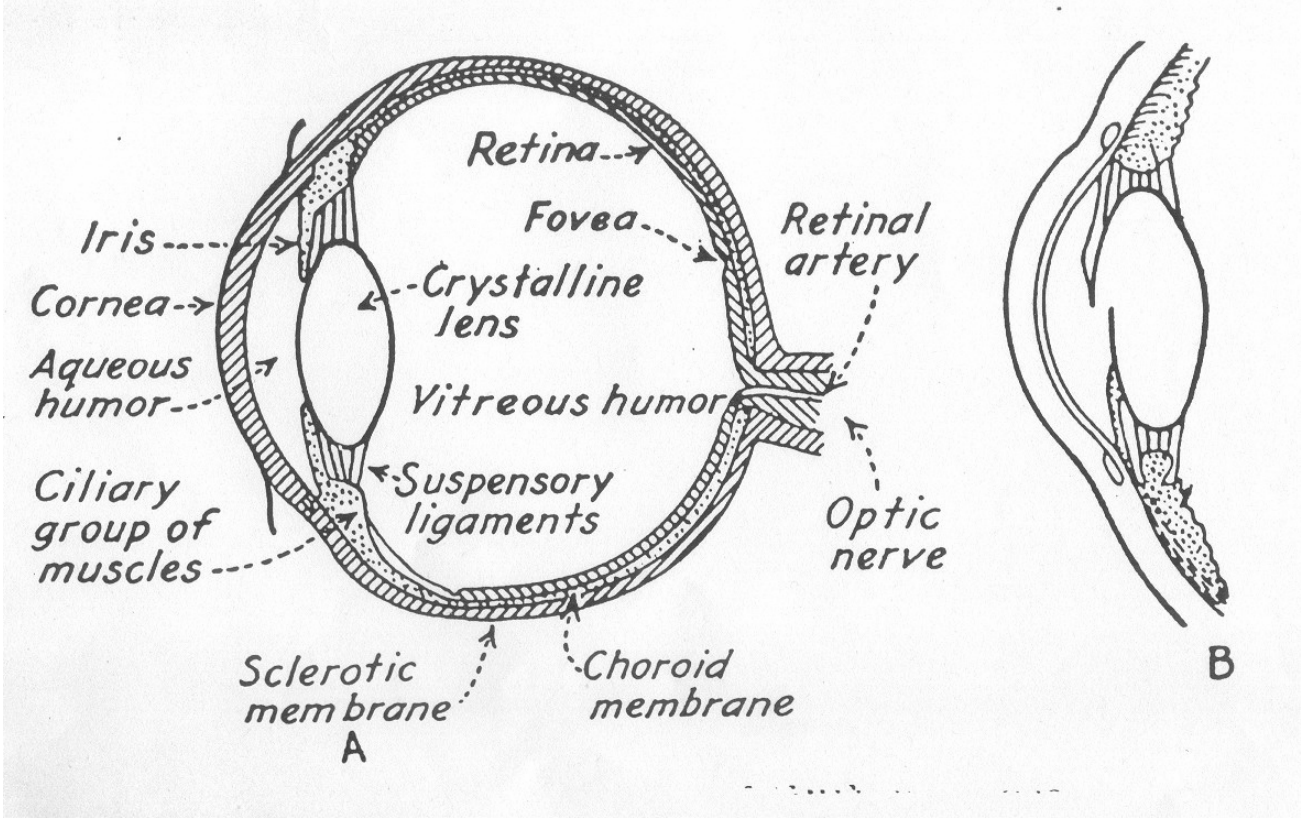

Fig. 1 Structure of Eye

Iris – a diaphragm that regulates amount of light by expanding contracting also know as (Pupil), lens that focuses under the control of ciliary muscles forms image on to the retina. The lens is crystalline in nature. Lastly there is a screen like structure called retina that is holding a lot of - optic nerves – that communicate with the brain. The central region has the greatest sensitivity and is called Fovea. Fovea is the most acute spot of vision where fine details are formed. Rest of the retina is responsible for orientation. The eye communicates through optic nerves located on the retina. They are a system of double nerves called Rods and Cones. Rods are responsible for Dim light / Night vision and Cones are mainly concentrated around or at Fovea and are responsible for form/color sensitivity.
As a result vision is of two types; (i) Photopic and (ii) Scotopic

Photopic vision involving cone cells and is used for discrimination of fine details for critical observation. They are densely packed and transmits sharp images. The cone cells have low sensitivity below 0.01 ft lamberts and cease to function < 0.001 ft lamberts. It must be mentioned that by definition 1 lambert is $\frac{1}{\pi}$ candles / m^2 and 1 ft lambert is $\frac{1}{\pi}$ candles / ft^2

Scotopic vision involving Rods takes over when brightness < 0.01 ft lambert. This vision has no color discrimination ability. Most images have gray appearance and are viewed as silhouettes lacking sharp details. Eyes have good ability to change from one to other. This shift in Luminosity and ability of eye to adjust is known as Purkinjee effect. Upon increase of intensity of illumination by a decrease in Pupil size producing clearer images with greater and fine details. Pupil diameter varies in the range of 1.2 – 2 mm. Eyes are error free and accommodate very

well. So eye functions under varying illumination levels by a change in pupil size together with change in Retinal Nerve System (i.e. cones/ rods) as shown in Table II.

Pupil Size or Opening	Light Received
Large	Dim Light
Small	High Illumination

Table II Pupil size Vs Light received

Eye is Unconscious to variations in natural light. Thus human eye is A chromatic with a dispersive power little greater than water. Hence for near vision eyes easily focus for blue and tires to focus for red. On the other hand for far vision eye easily focus for Red and strains to focus blue.

Table III shows the relationship of Eye opening to lens size, distance of object & color of focus.

Pupil Opening	Lens Shape	Object	Focus
Large	Flattest	Distant	Red
Small	Convex	Near	Blue

For objects distant 1m from the eye, there is no difference in accommodation.

Luminosity of Eye

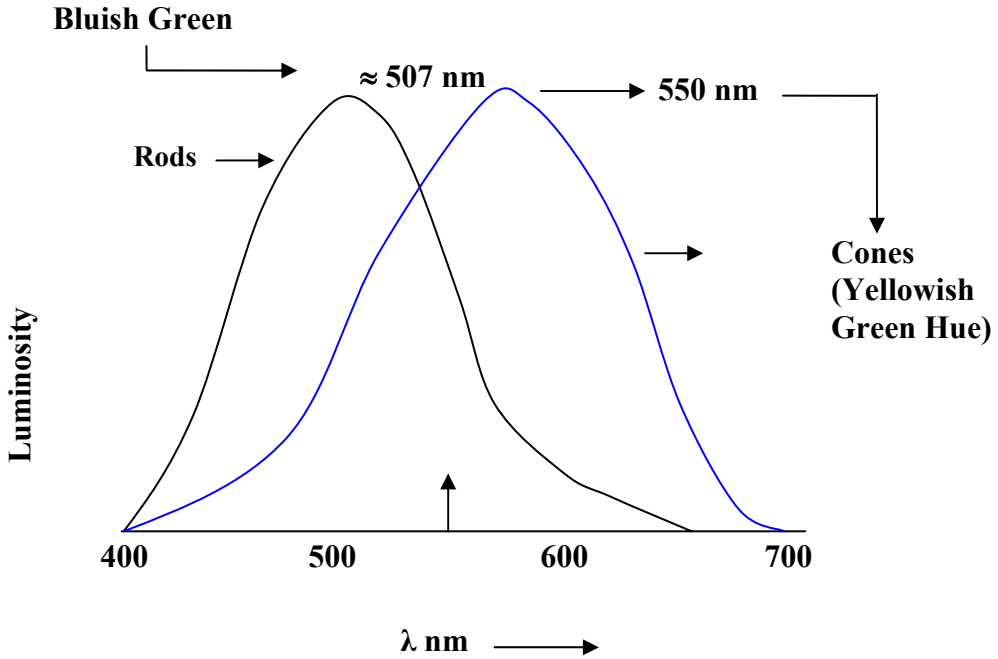

Fig. 2 Luminosity of Human eye

Fig. 2 shows the Luminosity curves for Human Eye. As may be seen Cone cells have peak sensitivity around 550nm while Rods have at 500nm.

Remember that seeing is the primary purpose of lighting is to be borne in mind. Good Lighting aims at Prevention or reduction of defective vision at the same time reduces waste of human resources. Improving the conditions of visibility.

However, visibility depends on the Size of the object, details of the object, level or Quantity of illumination, contrast or color in brightness and time required (available) for observation. It may appear that requirements are Contradictory as regards size, illumination, contrast and time. For effective deficiency in one of these is to be compensated by the other. So, Visibility depends on efficacy of individual. This in turn depends on eye defects, Eye fatigue which could be optical or physical. It also depends on amount of distraction present. Eye Fatigue are of two kinds Retinal and Muscular. Fatigue is enhanced by glare. Glare by definition is intense illumination in the plane of observation. Source of Glare – Front or behind the plane of attention tires maximum. Best in the plane of attention. Rotating or focusing muscles on the source of glare causes strain and fatigue. Similar fatigue in fact results by reading double impression obtained due to slipping paper in a printing press. After a days work – Pupil is dilated. A nights rest offsets this fatigue. Similarly weekend rest offsets fatigue of the working week. Pupiliary change call for good conditions for seeing. Eye defects arise due to Age Use or Abuse. No doubt Eyes ability to adjust to severe or unnatural conditions – gets injured in the long run. Defective vision may be due to difference in size and location of images by way of Refractory errors. Easy limited tasks lead to no defects. Lower Retinal Sensibility calls for larger pupil diameter and higher illumination levels. Seeing is not instantaneous process. Countless impressions are formed on the retina. Good illumination looks for producing clear and quick images.

Lecture Summary

- A human eye resembles a camera in structure and function.
- Important parts of a human eye
    - Iris / pupil
    - Lens
    - Retina
- Types of vision
    - Photopic (fine image details and color discrimination, due to cone cells).
    - Scotopic (functions in dim light and no image details, due to rod cells)
- Human eye is achromatic in nature
- Dispersive power of human eye is little greater than water
- Purkinjee Effect – shift of luminosity and ability of eye to adjust
- Maxima sensitivity of
    - cone cells – 550nm (yellowish green hue)
    - rod cells – 507nm (bluish green)
- Good lighting
    - Prevention of defective vision
    - Optimization of resources
    - Improving conditions of visibility
- Visibility depends on – (Observer Issues)
    - size / details of object

    - level / quality of illumination
    - contrast / color
    - available time
- Visibility depends on – (Observer Issues)
    - efficacy of individual
    - one's eye defects
    - optical / physical fatigue
    - distraction
- Causes of fatigue –
    - rotating source
    - focusing on the source of glare
    - reading double impression
    - after a days work pupil is dilated
- A nights rest offsets fatigue due to a days work
- Visibility reduces due to eye defects and fatigue
- Eye defects caused due to –
    - Aging
    - Use
    - Abuse
- Good illumination looks for producing clear and quick images

Tutorial Questions

- Which is the most acute spot in human eye?

  Fovea as it accounts for the fine details of the image formed.

- What are the two types of vision?

  Photopic & Scotopic vision.

- Distinguish between rod cells & cone cells.

  Rod cells – scotopic vision, functions in dim light when brightness < 0.01 ft-L, no color discrimination, lack sharp details

  Cone cells – photopic vision, ceases to function in dim light, color discrimination, fine details

- How does eye communicate with the brain?

  Through a set of optic nerves – the double nerve system i.e. Rods and Cones

- What is the diameter of pupil?

  1.2 – 2 mm

- How does eye functions under varying illumination?

  By a change in pupil size together with change in retinal nerve system

- Why is red color used for stop signal?

  The eye can easily sense red color from a distance due to its large wavelength so that one can get enough time to react & stop.