

EE293 ILLUMINATION ENGINEERING
(Credits 4:0:0)

Unit I: Language of Light & Lighting

- Eye & vision
- Light & Lighting
- Light & Vision
- Light & Color
- Basic Concepts and Units
- Photometry and Measurement
- Quantity and Quality of Lighting

Light Theory

- The corpuscular theory - Newton
 - luminous bodies emits radiant energy in particles.
- The wave theory
 - light is the resultant of molecular vibration in the luminous material.
- The electromagnetic theory
 - radiant energy is transmitted in the form of electromagnetic waves.
- The quantum theory
 - energy is emitted and absorbed in discrete quanta
- The theory of wave mechanics
 - the quantum and the wave theories

Light and the Energy Spectrum

- Visible light is electromagnetic radiation that is visible to the human eye, and is responsible for the sense of sight.
- Graphical representation of radiant energy in an orderly arrangement according to its wavelength is called a spectrum.
- Limits of the radiant energy spectrum extend over a range of wavelengths varying from a few micromicrons (10^{-10} cm) to one hundred thousand miles (1.6×10^{10} cm).
- Radiant energy in the visible spectrum has wavelengths between 0.38×10^{-4} and 0.76×10^{-4} cm.
- Angstrom unit (A), the micron (μ), and the millimicron ($m\mu$) are commonly used units of length in the visible spectrum band.

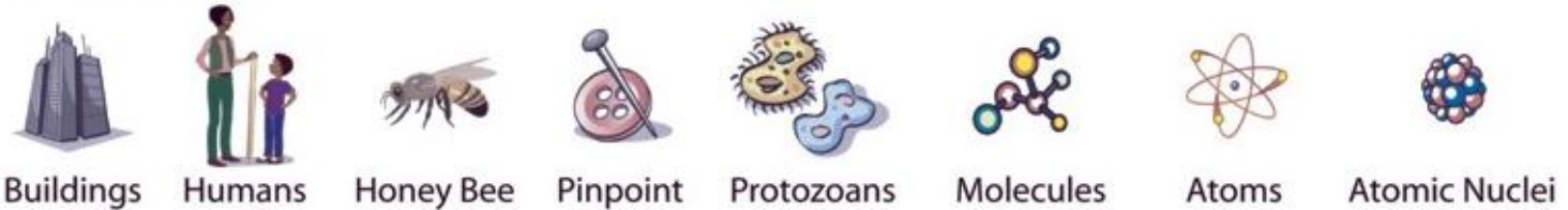
Energy Spectrum

Wavelength (meters)

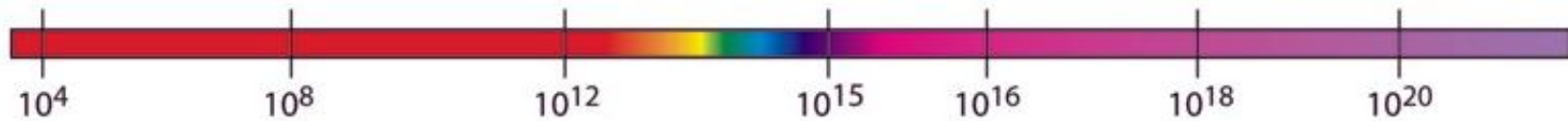
Radio 10^3 Microwave 10^{-2} Infrared 10^{-5} **Visible** $.5 \times 10^{-6}$ Ultraviolet 10^{-8} X-ray 10^{-10} Gamma Ray 10^{-12}



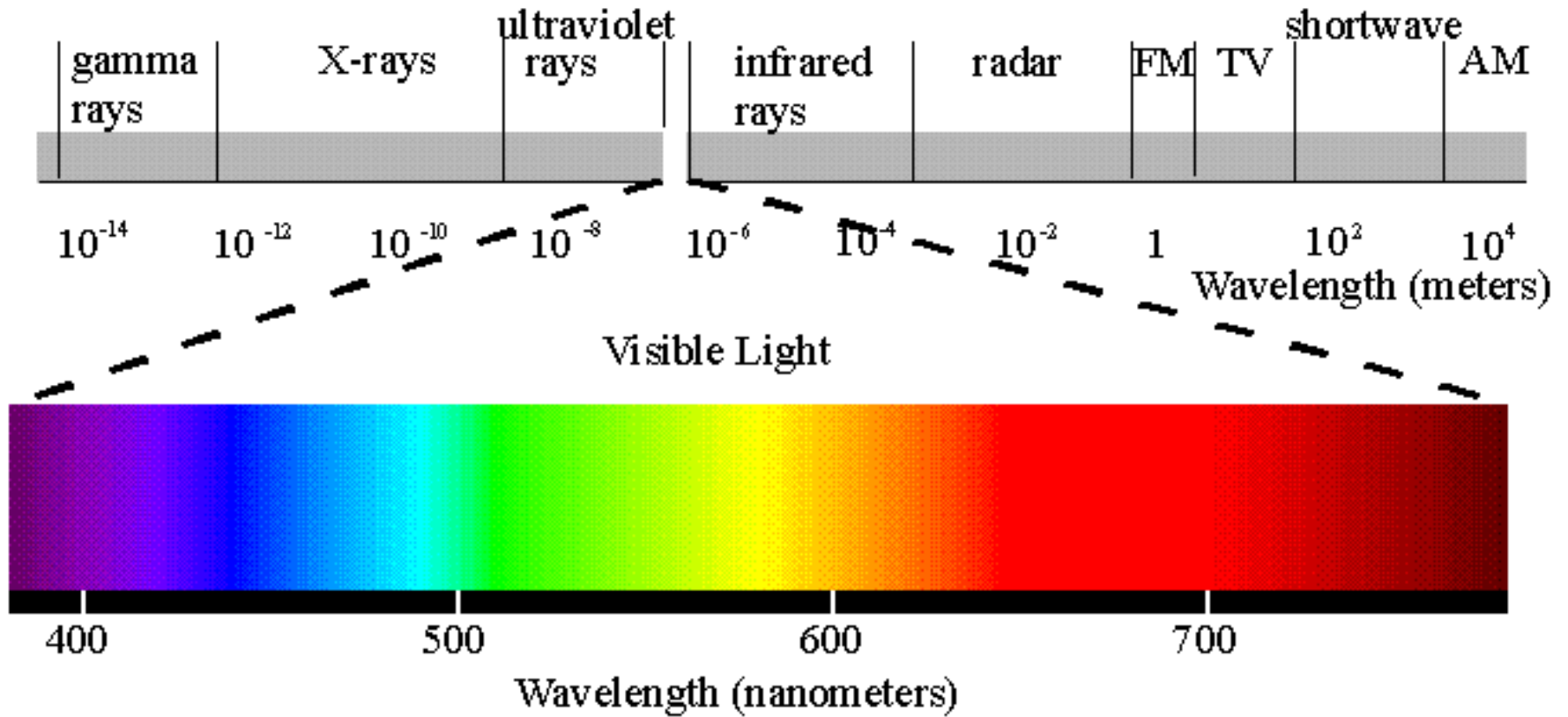
About the size of...



Frequency (Hz)



Visible light



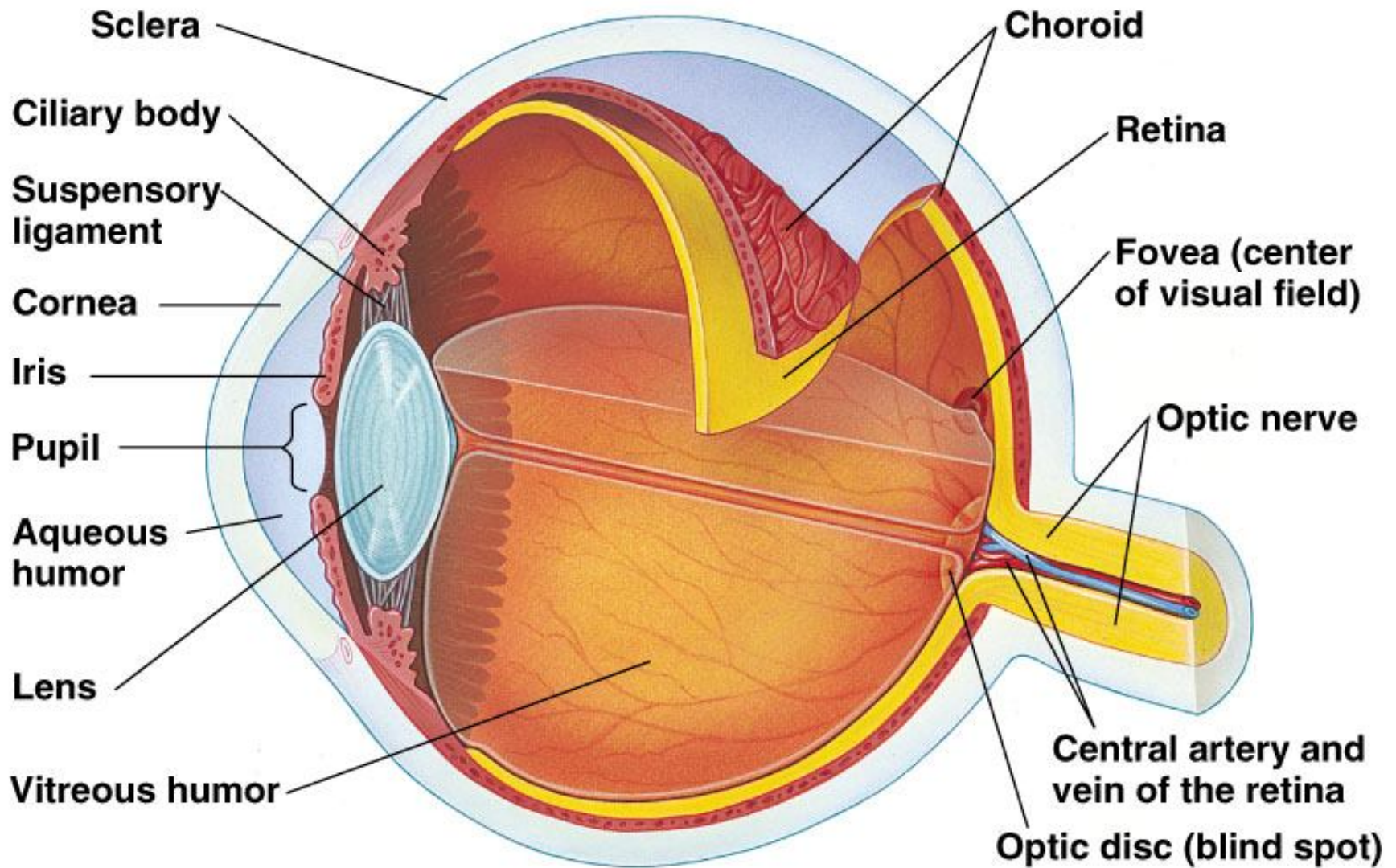
Light & Vision

- Joint professional responsibility of ophthalmologists and optometrists.
- Effect of poor illumination - experience temporary discomfort or disability that reduces their visual efficiency.
- The American Standard Safety Code for the Protection of Heads, Eyes and Respiratory Organs, published by the National Bureau of Standards, describes
 - the most common occupational eye hazards
 - means of preventing eye injuries
 - specifications for goggles designed to protect against glare, invisible radiation, fumes, and flying particles

Vision Process

- The functions of the eye is to transform a light stimulus into an impulse that may be transmitted through the nerve fibers to the brain.
- Impulse is analyzed and a reaction initiated.
- The eye should respond to
 - contrast and color
 - shape and depth
 - motion and direction
- Seeing skills must be learned and therefore are not uniformly developed in all individuals.

Human Eye



Parts of the Eye

- **Sclera:** a tough white layer of connective tissue that covers all of the eyeball except the cornea.
 - **Conjunctiva:** external cover of the sclera which keeps the eye moist.
- **Cornea:** transparent covering of the front of the eye.
 - Allows for the passage of light into the eye and functions as a fixed lens.

Parts of the Eye

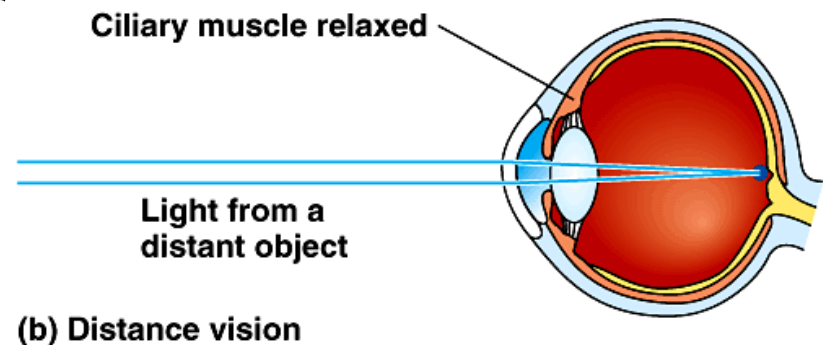
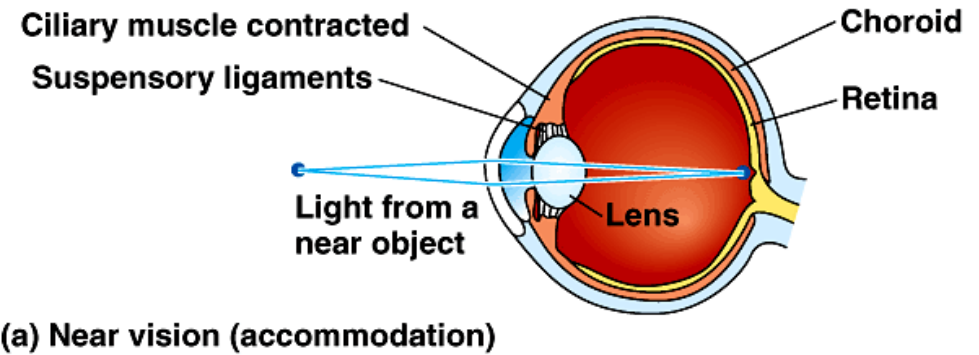
- **Choroid:** thin, pigmented layer lining the interior surface of the sclera.
 - Prevents light rays from scattering and distorting the image.
 - Anteriorly it forms the **iris**.
 - The iris regulates the size of the **pupil**.
- **Retina:** lines the interior surface of the choroid.
 - Contains photoreceptors.
 - Except at the **optic disk** (where the optic nerve attaches).

Focusing Light

- The **lens** and **ciliary body** divide the eye into two cavities.
 - The anterior cavity is filled with **aqueous humor** produced by the ciliary body.
 - The posterior cavity is filled with **vitreous humor**.
 - The lens, the aqueous humor, and the vitreous humor all play a role in focusing light onto the retina.

Focusing Light

- Accommodation is the focusing of light in the retina.
- Mammals focus by changing the shape of the lens.
 - The lens is flattened for distant objects.
 - The lens is rounded for near objects.



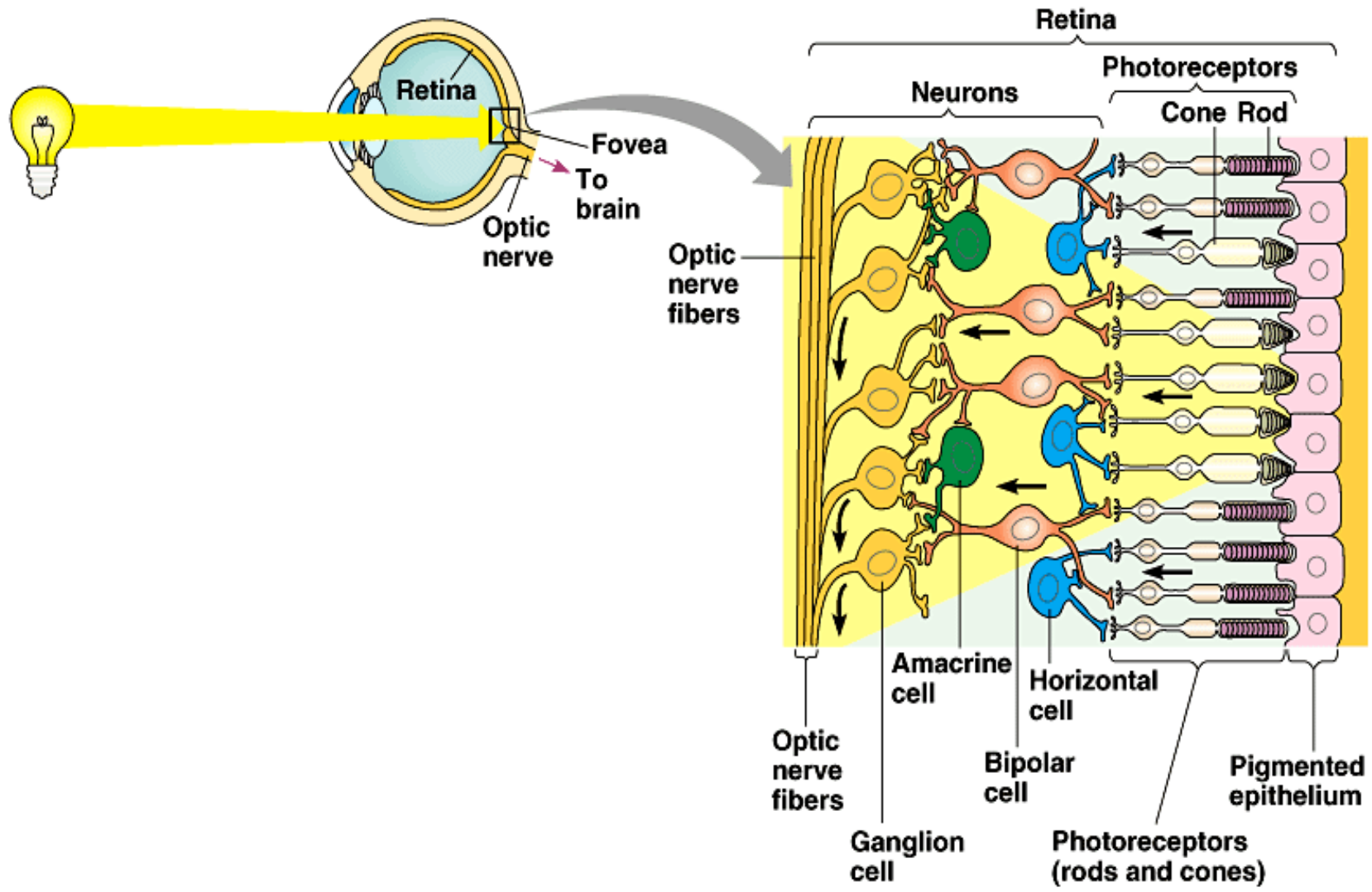
Photoreceptors of the retina

- Rod cells - light sensitive but do not distinguish colors.
- Rods approximately 0.00197 inch in diameter.
- Rhodopsin (retinal + opsin) is the visual pigment of rods.
- The absorption of light by rhodopsin initiates a signal-transduction pathway .

Cone Cells

- Not as light sensitive as rods but provide color vision.
- Cones approximately 0.000126 inch in diameter
- The cones are connected individually to single fibers of the optic nerve.
- Three types of cone cells each with unique photopsin (green cones, red cones, blue cones)
- Three types of nerve fibers through which primary color stimuli may be transmitted as distinct impulses.
- Brain's analysis of color depends on relative responses of each type of cone.
- Colorblindness is due to a deficiency, or absence, of one or more photopsins.

Vision



Factors of Vision

- ILLUMINATING ENGINEER

- Visual acuity
- Contrast
- Time or speed
- Brightness

- EYE SPECIALIST

- Visual acuity
- Visual efficiency
- Visual speed
- Visual comfort
- Visual health

Visual acuity

- Visual acuity is the ability to distinguish fine detail.
- Ratio of the distance at which a given line of letters on a Snellen test chart can be seen by the observer being tested to the distance at which an observer with normal vision could see it.

Contrast

- Contrast is the difference in brightness between the object and its background divided by the brightness of the background

$$C = \frac{B_1 - B_2}{B_1}$$

where

C = contrast

B_1 = brightness of background

B_2 = brightness of object

Speed of Vision

- It takes time to see.
- Speed of vision is a function of task brightness.

Brightness

- Visual sensation produced by an object.
- As visual sensation increases, the object is said to be brighter.
- It is a function of reflectance and illuminance.
- White paper has higher reflectance than gray paper.
- As brightness increases, it becomes easier to see.