PARMAR SSC

HUMAN EYE AND VISION

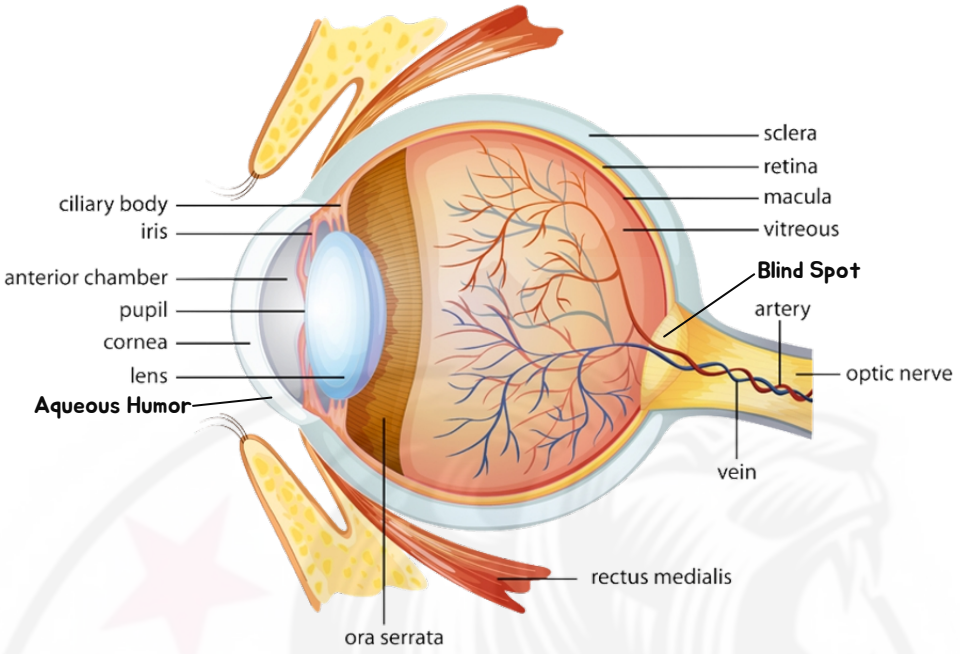
Lecture - 6



BY PARMAR SIR

HUMAN EYE

Anatomy of the Human Eye



CORNEA

- It is the transparent and front part of human eye.
- It is responsible for the majority of the refraction (bending) of light as it enters the eye.
- In eye donation, only cornea is used, not the entire eye.

PUPIL

- It is a black circular opening in the center of the iris.
- It regulates the amount of light entering the eye.

VITREOUS HUMOUR

- It is jelly-like substance filling the inside of the eye.
- It helps in maintaining the eye shape.

BLIND SPOT

- The blind spot in your eye is the point in the retina where the optic nerve exits the eye.
- This area has no light-sensitive cells, so it cannot detect light.

AQUEOUS HUMOR

- It is the clear fluid between cornea and lens.
- It maintains pressure, nourishes the cornea and lens.

IRIS

- It is the coloured part of the eye that surrounds the pupil.
- It controls the size of the pupil.

LENS

- It is transparent and flexible structure.
- It focuses light ray onto the retina by changing shape (accommodation).

RETINA

- It is a light-sensitive layer at the back.
- It is the spot where image is formed.
- In retina, optical energy is converted into electrical energy by photoreceptor cells.

TWO TYPES OF PHOTORECEPTOR CELLS

Rods - (black and white / night vision).
Cones - (color and daytime vision).

OPTIC NERVE

- The optic nerve is a bundle of nerve fibers that transmits visual information from the eye to the brain.

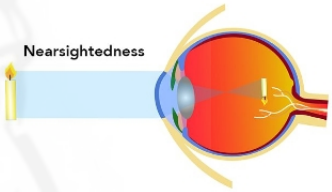
Power of Accommodation

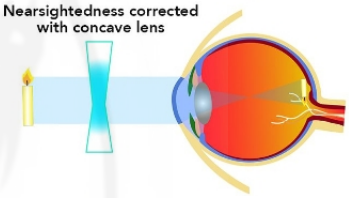
- The power of accommodation is the **ability of the eye to adjust its focal length to focus on objects at different distances.**
- The **ciliary muscles contract to thicken the lens**, which increases its refractive power and allows the eye to focus on nearby objects.
- The **ciliary muscles relax to flatten the lens**, which decreases its refractive power and allows the eye to focus on distant objects. This is known as power of accommodation.
- The least distance of **distinct vision is 25 cm.**

Defects of Eye

Myopia/Nearsightedness

- Myopia also known as nearsightedness, which means that you can see objects that are near clearly but have difficulty seeing objects that are farther away.
- To correct myopia, **Concave lens (-ve power lens) is used.**
- Focal length decreases and power increases.
- Image is formed in front of the retina.

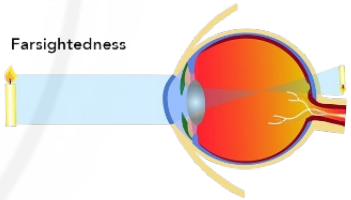


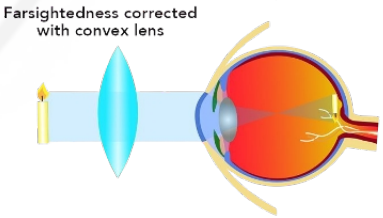




Hypermetropia/Far Sightedness

- Hypermetropia means farsightedness which means that you can see objects that are far away but have difficulty seeing objects that are close.
- It usually occurs above the age of 40 years.
- To correct **hypermetropia, Convex lens (+ve power lens) is used.**
- Image formed behind the retina.
- Light focuses behind the retina instead of focusing on the retina.

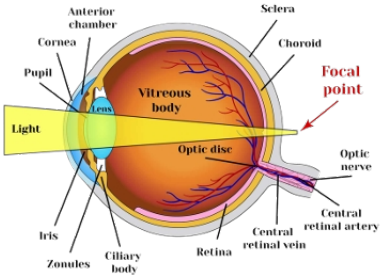






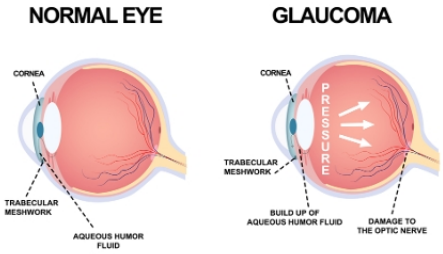
Presbyopia

- Presbyopia is the gradual loss of your eyes' ability to focus on nearby objects.
- In presbyopia, the lens of eye hardens with age (loses flexibility).
- It usually occurs above the age of 50 years.
- **Correction: Concave (upper part) + Convex lens or bifocal lens (lower part).**





Glaucoma



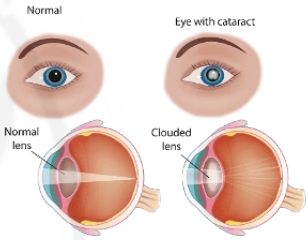
- Glaucoma is an eye condition that damages your eye's optic nerve.
- This causes the eye pressure to increase, leading to permanent vision loss.
- Glaucoma is generally hereditary (not curable).

Trachoma

- Trachoma is a disease of the eye caused by infection with the bacterium Chlamydia trachomatis.
- Trachoma leads to corneal clouding or scarring which is responsible for irreversible vision loss. The disease itself is not curable in the later stages.

Tonometry is an eye exam that measures the pressure inside your eyes, or intraocular pressure (IOP). It is used to screen for glaucoma and monitor how well glaucoma treatments are working.

Cataract



- The clear lens of the eye becomes cloudy and the vision becomes blurry. This clouding happens as the proteins in the lens break down and clump together.

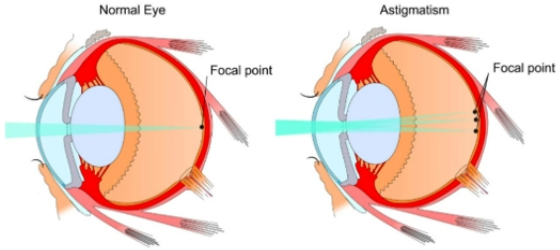
Colour Blindness

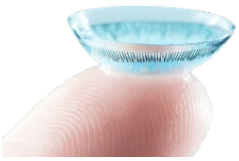
- Colour blindness (or color vision deficiency) is a condition where a person has difficulty seeing certain colors correctly.
- It is a hereditary condition.
- It happens when cone cells in the retina (which detect color) are missing or not working properly.



Astigmatism

- Astigmatism occurs when the cornea or lens has an irregular (oval) shape instead of being perfectly round.
- Due to this, light does not focus at a single point on the retina, causing blurred vision.
- It can lead to eye strain, headaches, and difficulty in clear vision.
- The eye surface becomes uneven, scattering light and forming distorted images.
- It is corrected using cylindrical lenses, contact lenses, or LASIK surgery.

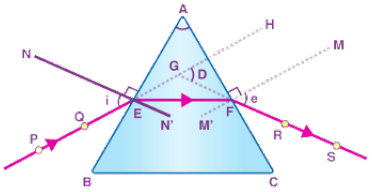






Light

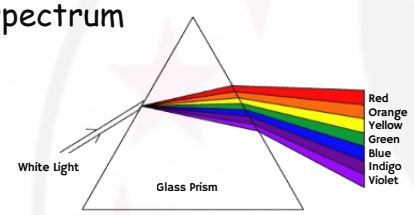
Refraction of Light through a Prism



- When light passes through a prism, it undergoes refraction, which means it bends as it changes speed moving from one medium (like air) to another (glass). This bending occurs because light travels at different speeds in different media.
- More wavelength = Less deviation.

Dispersion of White Light through Prism

- Dispersion is the process by which white light splits into its constituent colors when it passes through a glass prism.
- **White light is made up of seven colors:** Violet, Indigo, Blue, Green, Yellow, Orange, and Red (VIBGYOR). When it passes through a glass prism, it slows down and bends due to refraction, as glass is denser than air.
- Each color has a different wavelength and bends at a different angle → violet bends the most and red bends the least.
- This difference in bending causes the light to spread out into a band of colors, forming a visible spectrum



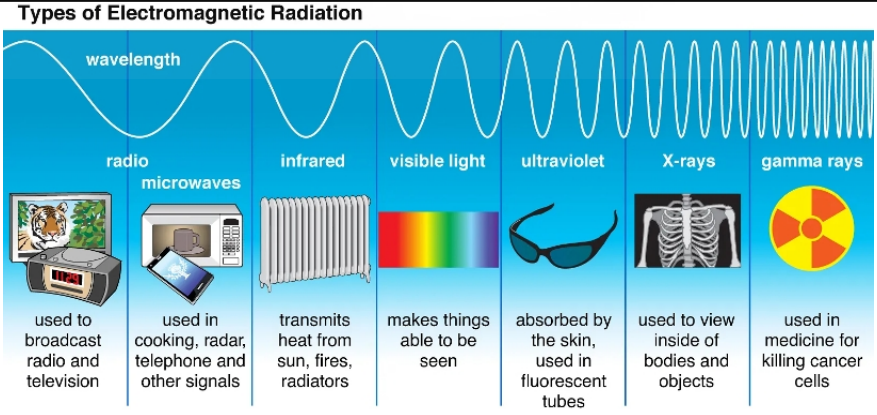
- **Red light:** More speed = less refractive index
- **Violet light:** Less speed = more refractive index
- Red light has maximum wavelength hence it deviates the least.
- Violet light has minimum wavelength hence it deviates the most.

- If a second prism is placed inverted after the first prism, the dispersed light recombines to form white light again.
- Isaac Newton first performed the prism experiment in the 1660s.

$$\textit{Refractive Index } (n) = \frac{\textit{Speed of light in air}}{\textit{Speed of light in prism}}$$

Electromagnetic Spectrum

- The electromagnetic spectrum is the complete range of electromagnetic waves arranged according to their wavelength or frequency. These waves all travel at the speed of light in a vacuum (3×10^8 m/s) but differ in their energy and applications.

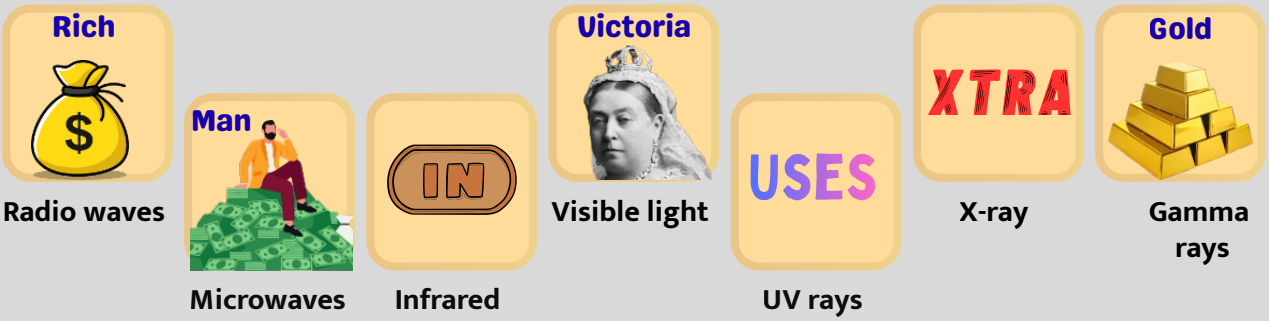


Left to right wavelength decreases, frequency increases and energy increase.

Wavelength:	10^3	10^{-2}	10^{-5}	10^{-6}	10^{-8}	10^{-10}	10^{-3}
Frequency:	10^6	10^9	10^{12}	10^{14}	10^{17}	10^{19}	10^{20}

TRICK TO REMEMBER

Rich — Man — In — Victoria — Uses — Xtra — Gold



Radio waves | Microwaves | Infrared | Visible light | UV rays | X-ray | Gamma rays

Radiation Type	Discovered By
Radio waves	Heinrich Hertz
Microwaves	Percy Spencer
Infrared rays	William Herschel
Visible light	Isaac Newton
UV rays	Johann Wilhelm Ritter
X-rays	Wilhelm Roentgen
Gamma rays	Paul Villard

Planck's Constant

- Planck's constant is a fundamental constant in quantum physics that relates the energy of a photon to its frequency.

$$E = hf$$
$$E = \frac{hc}{\lambda}$$

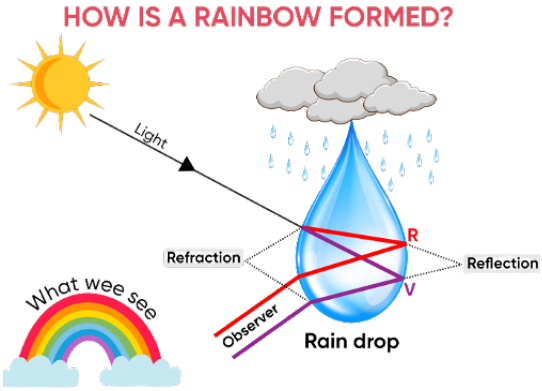
E = Energy of the photon (in joules, J)
h = Planck's constant
f = Frequency of the radiation (in hertz, Hz)
c = Speed of light
λ = Wavelength

h = 6.626 × 10⁻³⁴ J-sec

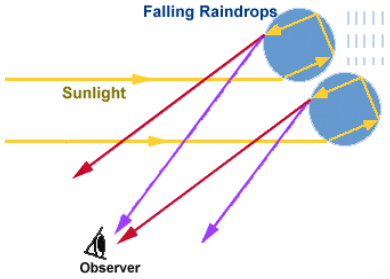
- Energy of a photon is directly proportional to its frequency and inversely proportional to its wavelength.

Rainbow Formation

- A rainbow is formed due to the refraction (two), dispersion, and reflection of sunlight in water droplets present in the atmosphere.
- Sunlight enters a raindrop and bends (refracts) because water is denser than air. Inside the drop, the light splits into its 7 colors (VIBGYOR) because each color bends at a slightly different angle. The light reflects off the inside surface of the raindrop. As it exits the drop, the light bends again, and the colors spread out more.







Primary Rainbow

- It is formed due to one refraction and one internal reflection inside water droplets.
- The colour order is V → R (VIBGYOR).

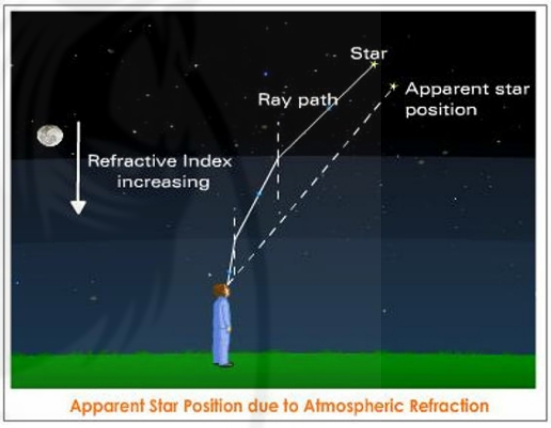
Secondary Rainbow

- It is formed due to two internal reflections and refraction inside water droplets.
- During multiple reflections, more light is lost (absorbed and scattered), so the secondary rainbow appears fainter.
- The colour order is reversed R → V (ROYGBIV).

Refraction in Atmosphere

Twinkling of Star

- The twinkling of stars is caused by the refraction of light as it passes through the Earth's atmosphere.
- Starlight passes through Earth's atmosphere before reaching our eyes. The atmosphere is made up of many layers of air with varying temperatures and densities. As the light passes through these layers, it bends (refracts) continuously and slightly differently every moment. Because of this bending, the position and brightness of the star seem to change → making it appear to "twinkle".



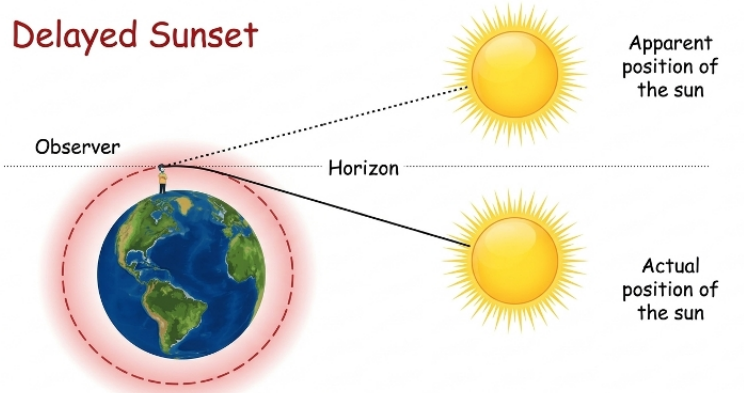
Apparent Star Position due to Atmospheric Refraction

Advanced Sunrise and Delayed Sunset

- Advanced sunrise and delayed sunset are both caused by the refraction of sunlight in Earth's atmosphere. Due to atmospheric refraction, we see the sun a little earlier before it actually rises (advanced sunrise), and a little longer after it sets (delayed sunset). This happens because the Earth's atmosphere bends the sunlight, making the sun appear slightly higher than it really is.

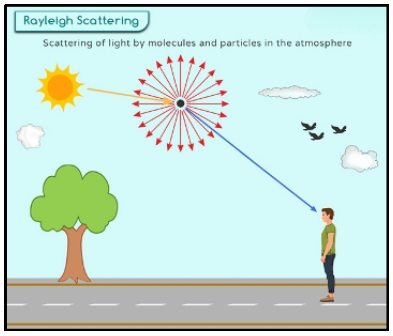
Alpenglow is a natural phenomenon where mountains appear to glow with a rosy or reddish hue, typically around sunrise or sunset.





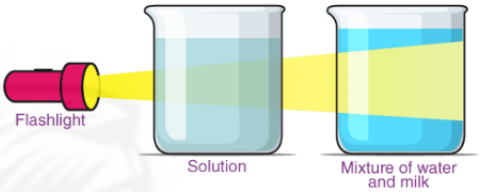
The size and distances of observer sun, and Earth are just for representation purposes.

Scattering of Light



- Scattering of light happens when light hits small particles (like dust, water droplets, or gas molecules) in the atmosphere and changes direction.
- Rayleigh talked about the scattering of light in 1871.

Tyndall Effect



- The Tyndall effect is the scattering of light by particles in a colloid or suspension, which makes the light beam visible.
- Light rays hit the particles in a colloid, these particles scatter the light in all directions. The scattered light makes the path of the light beam visible.

Blue Colour of Sky

- Shorter wavelengths (blue/violet) scatter more (travels as shorter or smaller waves) than longer wavelengths (red). That's why the sky looks blue during the day (blue light is scattered in all directions).
- Our sky appears black without atmosphere.

Red Colour of Sun during Sunrise/Sunset

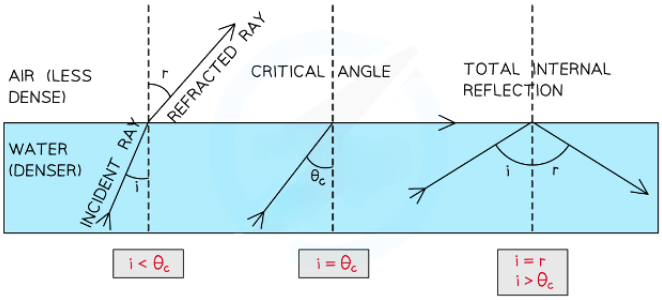


- During sunrise and sunset, the sun is low on the horizon, so its light has to travel a longer distance through the Earth's atmosphere. In this long path, shorter wavelengths like blue and violet are scattered away, while red light, which scatters the least, manages to reach our eyes. That's why the sky appears reddish-orange during these times.

Danger Signals in Red

- Danger signals are often in red because it has the longest wavelength and scatters the least, making it visible from a distance even in poor visibility conditions like fog or smoke. Additionally, red naturally catches attention and signals alert or warning, making it the ideal color for danger signals.

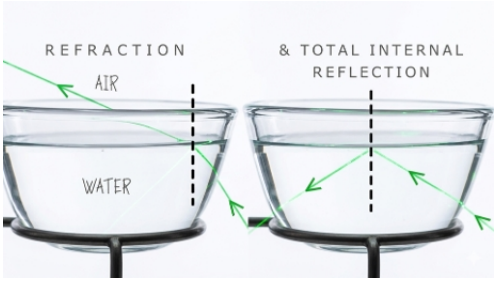
Total Internal Reflection (TIR)



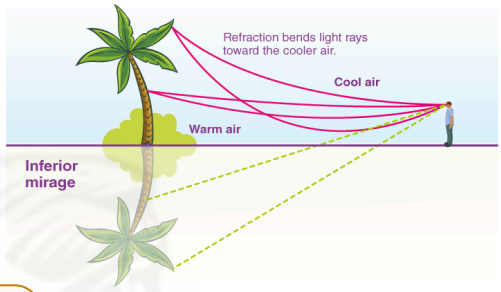
- Total internal reflection is a phenomenon where light, traveling from a denser medium to a less dense medium, is reflected back into the denser medium instead of being refracted. **E.g.** Mirage, optical fibres, etc.
- This phenomenon is also responsible for optical illusions.

Conditions of Total Internal Reflection

- Light should travel from denser to rarer medium.
- Angle of incidence must be greater than the critical angle (The critical angle is the minimum angle of incidence at which light is totally reflected inside the denser medium.



- A mirage is an optical illusion caused by the refraction of light through layers of air at different temperatures. On a hot day, the layer above the ground gets warm. The light ray gets refracted when light moves through the cold air and into the hot layer.



Uses of Optical Fibres

- Optical fibers have a wide range of uses, primarily in telecommunications, computer networking, and medical applications.



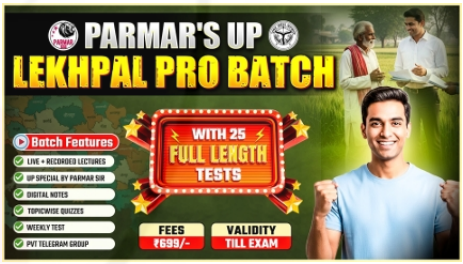
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