⚡ The Human Eye and the Colourful World

Science | Chapter 10 | NCERT

1. The Human Eye

→ Eye is the most valuable & sensitive **sense organ** — lets us see the colourful world; closing eyes we can identify objects by smell/taste/touch/sound but NOT by colour.

→ Human eye works like a **camera** — its lens system forms an image on a light-sensitive screen called the **retina**.

Structure of the Eye

① **Cornea** — thin transparent membrane; light enters here; forms bulge on front of eyeball; MOST refraction happens at cornea's outer surface.

② **Crystalline lens** — fibrous jelly-like structure; provides only the finer adjustment of focal length.

③ **Iris** — dark muscular diaphragm behind cornea; controls size of pupil.

④ **Pupil** — regulates & controls amount of light entering the eye.

⑤ **Retina** — delicate membrane, huge no. of light-sensitive cells; eye lens forms an **inverted real image** here.

⑥ **Optic nerve** — sends electrical signals generated by light-sensitive cells to the brain, which then processes them so we perceive objects correctly.

★ Eyeball is approx. spherical, diameter ≈ 2.3 cm

2. Power of Accommodation

→ Curvature of eye lens can be modified by **ciliary muscles** → changes its focal length.

→ Muscles **relaxed** → lens becomes thin → focal length increases → distant objects seen clearly.

→ Muscles **contract** → lens curvature increases → lens becomes thicker → focal length decreases → nearby objects seen clearly.

ACCOMMODATION → The ability of the eye lens to adjust its focal length so as to focus objects at varying distances on the retina.

NEAR POINT → Minimum distance at which objects can be seen most distinctly without strain = **least distance of distinct vision**. For a young adult, near point ≈ **25 cm**.

FAR POINT → Farthest point up to which the eye can see objects clearly = **infinity** for a normal eye.

★ Normal eye sees clearly objects between 25 cm and infinity — focal length CANNOT decrease below a certain minimum limit

⚠परीक्षाकेलिए| Focal length of eye lens cannot be decreased below a minimum limit — that's why holding a page too close blurs the image / strains the eye.

→ Old age → crystalline lens becomes milky & cloudy = **Cataract** → partial/complete loss of vision → restored by cataract surgery.

3. Defects of Vision and their Correction

→ Eye gradually loses power of accommodation → vision blurred due to **refractive defects**.

→ Three common defects: **Myopia**, **Hypermetropia**, **Presbyopia** — corrected using suitable spherical lenses.

(a) Myopia (Near-sightedness)

→ Sees **nearby** objects clearly, CANNOT see **distant** objects distinctly.

→ Far point is nearer than infinity — image of a distant object forms **in front of retina**, not on it.

① Causes: excessive curvature of eye lens, OR

② elongation of the eyeball.

CORRECTION → Use a **concave lens** (diverging) of suitable power — brings the image back onto the retina.

(b) Hypermetropia (Far-sightedness)

→ Sees **distant** objects clearly, CANNOT see **nearby** objects distinctly.

→ Near point farther than normal (25 cm) — image of closeby object focussed **behind the retina**.

① Causes: focal length of eye lens too long, OR

② eyeball has become too small.

CORRECTION → Use a **convex lens** (converging) of appropriate power — provides extra focussing power to form image on retina.

(c) Presbyopia

→ Power of accommodation decreases with **ageing** — near point gradually recedes; ciliary muscles weaken, lens loses flexibility.

→ If person suffers from BOTH myopia & hypermetropia → needs **bi-focal lenses** (upper part concave for distant vision, lower part convex for near vision).

★ Refractive defects today can also be corrected using contact lenses or surgery

⚠परीक्षाकेलिए| Numericals: Use Lens formula $1/f = 1/v - 1/u$ and Power $P = 1/f$ (f in metres). For myopia correction, $f = -$(far point distance). For hypermetropia, use $1/f = 1/v - 1/u$ with $v = -$(actual near point), $u = -25$ cm.

Defect	Can see	Image forms	Correcting Lens
Myopia	Near objects	In front of retina	Concave
Hypermetropia	Distant objects	Behind retina	Convex
Presbyopia	Reduced accommodation (age)	—	Bi-focal

4. Refraction of Light through a Prism

→ In a glass slab (parallel surfaces) → emergent ray is **parallel** to incident ray, only laterally displaced.

→ Prism = two triangular bases + three rectangular lateral surfaces, inclined to each other.

ANGLE OF PRISM → The angle between its two lateral refracting faces (∠A).

→ Ray entering air → glass at surface AB bends **towards normal**; at surface AC, glass → air, bends **away from normal**.

ANGLE OF DEVIATION → The angle (∠D) at which the emergent ray bends with respect to the direction of the incident ray, due to the peculiar (non-parallel) shape of the prism.

KEY RAYS & ANGLES →

PE = Incident ray | EF = Refracted ray | FS = Emergent ray | ∠i = angle of incidence, ∠r = angle of refraction, ∠e = angle of emergence, ∠D = angle of deviation

5. Dispersion of White Light by a Glass Prism

→ Prism splits incident white light into a band of colours = **Violet, Indigo, Blue, Green, Yellow, Orange, Red**.

★ Remember the order using acronym: VIBGYOR

SPECTRUM → The band of coloured components of a light beam.

DISPERSION → The splitting of light into its component colours.

→ Different colours bend through **different angles** w.r.t. incident ray — **red bends the LEAST, violet bends the MOST**.

Newton's Experiment

→ Isaac Newton first used a glass prism to obtain sunlight's spectrum. A 2nd identical prism placed in **inverted position** recombined all spectrum colours back into white light.

→ Conclusion: sunlight is made up of **seven colours**. Any light giving a spectrum like sunlight's is called **white light**.

Rainbow Formation

RAINBOW → A natural spectrum in the sky after rain, caused by dispersion of sunlight by tiny water droplets in the atmosphere.

① Always formed in direction OPPOSITE to the Sun.
② Water droplets act like small prisms — they refract & disperse sunlight,
③ then reflect it internally, and finally refract it again on exit.

★ Rainbow also visible on a sunny day looking at sky through a waterfall/fountain with Sun behind you

6. Atmospheric Refraction

ATMOSPHERIC REFRACTION → Refraction of light by the earth's atmosphere (medium of gradually, continuously changing refractive index).

→ Example: flickering of objects seen through hot air above a fire — hot air is less dense, lower refractive index than cooler air above → apparent position fluctuates.

Twinkling of Stars

→ Starlight undergoes continuous refraction entering earth's atmosphere (changing refractive index).

→ Atmosphere bends starlight **towards normal** → apparent position of star slightly **higher** than actual position, especially near horizon.

→ Apparent position keeps changing (atmosphere not stationary) — stars are near **point-sized sources**, so amount of light entering eye fluctuates → star appears sometimes brighter, sometimes fainter = **twinkling effect**.

⚠परीक्षाकेलिए| Why don't planets twinkle? — Planets are much closer to Earth, seen as EXTENDED sources (collection of many point sources). Variations from individual points average out to zero → twinkling effect nullified.

Advance Sunrise & Delayed Sunset

→ Sun visible ≈ **2 minutes before** actual sunrise and ≈ **2 minutes after** actual sunset, due to atmospheric refraction.

ACTUAL SUNRISE → The actual crossing of the horizon by the Sun.

→ Time difference between actual & apparent sunset ≈ 2 minutes; apparent **flattening of Sun's disc** at sunrise/sunset is also due to atmospheric refraction.

★ Since atmosphere bends light towards normal, Sun is seen slightly above its actual position at the horizon

7. Scattering of Light

→ Path of light beam through a **true solution** is NOT visible; path through a **colloidal solution** (larger particle size) becomes visible.

Tyndall Effect

→ Earth's atmosphere = heterogeneous mixture of smoke, water droplets, dust, air molecules.

TYNDALL EFFECT → Scattering of light by colloidal particles, making the path of a light beam visible (e.g. sunbeam through smoke-filled room, sunlight through forest canopy, mist).

→ Colour of scattered light depends on particle size: **very fine particles** scatter mainly **blue**; **larger particles** scatter longer wavelengths; large enough particles → scattered light appears **white**.

Why is the Clear Sky Blue?

→ Air molecules & fine particles are smaller than wavelength of visible light → more effective at scattering **shorter wavelengths (blue)** than longer wavelengths (red).

→ Red light's wavelength ≈ **1.8 times** greater than blue → blue scattered far more strongly → scattered blue light reaches our eyes.

⚠परीक्षाकेलिए| If earth had no atmosphere → no scattering → sky would appear DARK. This is why sky looks dark to astronauts / at very high altitudes (scattering not prominent there).

Why are Danger Signals Red?

REASON → Red light is scattered the LEAST by fog/smoke (longest wavelength) — so it can travel the longest distance and be seen clearly, hence used for danger/stop signals.

What You Have Learnt — Summary

① Ability of eye to focus near & distant objects by adjusting focal length = **Accommodation**.

② Near point (least distance of distinct vision) ≈ **25 cm** for a young adult.

③ **Myopia** → concave lens; **Hypermetropia** → convex lens; eye loses accommodation power in old age (Presbyopia).

④ Splitting of white light into component colours = **Dispersion**.

⑤ **Scattering of light** causes the blue colour of the sky.

★ Revise all exam-alert boxes before the test — these are the most frequently asked concepts from this chapter