NCERT EXEMPLAR CLASS 10 SCIENCE CHAPTER 11

The Human Eye and the Colourful World

Class: X | **Subject:** Science	**Questions:** 14 MCQ + 10 SA + 6 LA	**Topics:** Eye, Vision, Light Phenomena

STUDY GUIDE CONTENTS

SECTION 1 -- KEY TERMS / GLOSSARY

Human Eye	A natural optical instrument that enables vision by refracting light onto the retina.
Cornea	The transparent curved front surface of the eye; responsible for most refraction (~2/3 of total).
Iris	The colored ring-shaped muscular diaphragm that controls the size of the pupil.
Pupil	The dark circular opening in the iris through which light enters the eye.
Crystalline Lens	A flexible bio-convex lens behind the iris whose curvature is controlled by ciliary muscles.
Ciliary Muscles	Muscles attached to the lens that change its curvature to adjust focal length.
Retina	The light-sensitive screen at the back of the eye where the image is formed.
Aqueous Humour	Watery fluid between the cornea and lens that maintains eye pressure.
Vitreous Humour	Jelly-like fluid filling the main cavity of the eye behind the lens.
Optic Nerve	Nerve that carries visual signals from the retina to the brain.
Power of Accommodation	The ability of the eye lens to adjust its focal length to see objects at different distances.
Near Point	The closest point at which an object can be seen clearly. Normal = 25 cm.
Far Point	The farthest point at which an object is seen clearly. Normal = infinity.
Myopia	Short-sightedness. Cannot see distant objects; image forms in front of retina. Corrected by concave lens.
Hypermetropia	Far-sightedness. Cannot see near objects; image forms behind retina. Corrected by convex lens.
Presbyopia	Age-related loss of accommodation due to stiffening of eye lens. Corrected by bifocal lenses.
Cataract	Clouding of the eye lens leading to blurred vision; corrected by surgery.
Dispersion	Splitting of white light into its constituent colours (VIBGYOR) on passing through a prism.
Scattering	Redirection of light by particles in all directions. Blue scattered most by atmosphere (Rayleigh scattering).
Refraction	Bending of light as it passes from one medium to another of different optical density.
Twinkling of Stars	Caused by atmospheric refraction -- the refractive index of air layers keeps changing, shifting the star light.
Rainbow	A natural spectrum formed by dispersion of sunlight by water droplets after rain. Involves refraction, total internal reflection, and dispersion.
VIBGYOR	Order of colours in visible spectrum: Violet, Indigo, Blue, Green, Yellow, Orange, Red.
Angle of Deviation	The angle between the incident ray and the emergent ray when light passes through a prism.
Atmospheric Refraction	Bending of light due to varying density of atmospheric layers; causes phenomena like twinkling of stars and advanced sunrise.

SECTION 2 -- KEY FORMULAE AND IMPORTANT VALUES

Formula / Value	Description	Example / Note
P = 1/f (f in metres)	Power of a lens in Dioptres (D)	f = -0.22 m -> P = -4.5 D (concave)
f = 1/P	Focal length from Power	P = -0.5 D -> f = -2 m (for myopia at 2 m)
Near Point (normal) = 25 cm	Minimum distance for clear vision	Also called Least Distance of Distinct Vision (D)
Far Point (normal) = infinity	Maximum distance for clear vision	Myope has limited far point
Power of lens for myopia: P = 1/f; f = -d (far point)	Concave lens; d = far point distance	Far pt = 2 m -> P = -0.5 D
Angle of Deviation (D) = angle between incident and emergent ray	For a prism	D increases for violet, less for red
n = c/v	Refractive index; c = 3x10<super rise="3" size="7">8</super> m/s	Higher n -> slower speed -> more bending
Scattering alpha 1/lambda<super rise="3" size="7">4</super>	Rayleigh scattering law (lambda = wavelength)	Short wavelength (Blue) scattered most

Tip / Remember: In air, all colours of white light travel at the SAME speed (3x10^8 m/s). Only in other media do they travel at different speeds causing dispersion.

SECTION 3 -- STRUCTURE OF THE HUMAN EYE

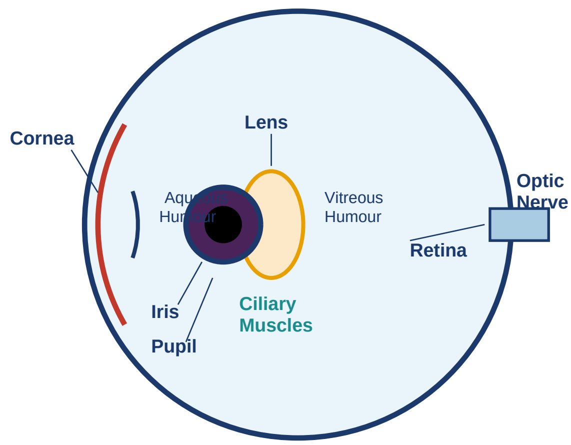


Fig. 11.1 -- Cross-section of the Human Eye

The human eye works like a camera. Light enters through the **cornea** (main refraction), passes through the **pupil** (size controlled by iris), is further refracted and focused by the **crystalline lens**, and forms an inverted, real image on the **retina**. The **optic nerve** carries electrical impulses to the brain which interprets the image as upright. The **ciliary muscles** change the curvature (and hence focal length) of the lens -- this is called **POWER OF ACCOMMODATION**.

Tip / Remember: Most refraction in the eye occurs at the OUTER SURFACE OF THE CORNEA, not the crystalline lens. The lens fine-tunes focus for different distances.

SECTION 4 -- VISION DEFECTS: SUMMARY TABLE

Defect	Also Called	Cause	What they See	Far Point	Correction
Myopia	Near-sightedness	Eyeball too long OR lens too curved	Near: clear; Distant: blurred	Closer than infinity	Concave (diverging) lens
Hypermetropia	Far-sightedness	Eyeball too short OR lens too flat	Distant: clear; Near: blurred	Infinity (normal)	Convex (converging) lens
Presbyopia	Old-age sight	Ciliary muscles weaken; lens stiffens	Both near & far blurred	Recedes with age	Bifocal lenses
Cataract	--	Lens becomes milky/opaque	Dim or hazy vision	--	Surgical removal

SECTION 5 -- LIGHT PHENOMENA: SUMMARY TABLE

Phenomenon	Cause (Medium)	Mechanism	Observable Effect
Dispersion of Light	Prism/Water droplets	White light splits into VIBGYOR	White -> Violet, Indigo, Blue, Green, Yellow, Orange, Red
Scattering (Rayleigh)	Atmospheric particles	Short lambda scattered more	Blue sky, white noon sun, red sunrise/sunset
Twinkling of Stars	Atmospheric layers	Changing refractive index bends light variably	Stars appear to shimmer; planets do not (extended sources)
Rainbow	Water droplets post-rain	Refraction + Internal Reflection + Dispersion	Arc of VIBGYOR in sky, sun behind observer
Reddish Sunrise/Sunset	Thick atmosphere at horizon	Blue scattered away, red travels	Sun looks red/orange; at noon sun looks white (short path)
Blue Sky	Air molecules	Blue light scattered to all directions	Sky appears blue from all directions
Blue sea/deep water	Water molecules	Scattering of sunlight	Deep sea appears bluish

SECTION 6 -- MULTIPLE CHOICE QUESTIONS (MCQ): SOLVED

MCQ Answer Key (Official NCERT): 1-(b), 2-(a), 3-(b), 4-(a), 5-(c), 6-(b), 7-(c), 8-(c), 9-(b), 10-(b), 11-(c), 12-(b), 13-(a), 14-(c)

Q1. A person cannot see distinctly objects kept beyond 2 m. This defect can be corrected by using a lens of power

(a) +0.5 D

(b) -0.5 D

(c) +0.2 D

(d) -0.2 D

Correct Answer: (b) -0.5 D

Explanation: The person cannot see beyond 2 m, so their far point = 2 m. This is **myopia** (short-sightedness). A concave lens is needed whose focal length = -far point distance = -2 m. Power P = 1/f = 1/(-2) = **-0.5 D**. Negative power confirms a diverging (concave) lens.

Tip / Remember: For myopia: P = -1/far_point_in_metres. Always negative for concave lens.

Q2. A student sitting on the last bench can read letters on the blackboard but is not able to read letters in his textbook. Which statement is correct?

(a) Near point has receded away

(b) Near point has come closer

(c) Far point has come closer

(d) Far point has receded away

Correct Answer: (a) Near point has receded away

Explanation: The student can see **distant** objects (blackboard) clearly but NOT near objects (textbook). This is **hypermetropia**. In hypermetropia, the near point moves AWAY from the normal 25 cm, i.e., the near point has **receded away**. The far point remains at infinity (or beyond normal) -- it has NOT come closer.

Tip / Remember: Hypermetropia: near point > 25 cm (receded away). Myopia: far point < infinity (moved closer).

Q3. A prism ABC (with BC as base) is placed in different orientations. A narrow beam of white light is incident. In which case does the third colour from the top correspond to the colour of the sky?

(a) (i)

(b) (ii)

(c) (iii)

(d) (iv)

Correct Answer: (b) (ii)

Explanation: The colour of the sky is **BLUE**. In dispersion through a prism, when light hits the face AB (with apex A at top), the order from top is: Violet (deviated most), Indigo, Blue, Green, Yellow, Orange, Red. So the THIRD colour from the top = **Blue**. This arrangement corresponds to orientation (ii) where the apex points upward on the left and light enters the left face, giving the standard VIBGYOR dispersion.

Tip / Remember: VIBGYOR order from top when apex is up: V=1st, I=2nd, B=3rd (Blue = sky colour), G=4th...

Q4. At noon the sun appears white as

(a) light is least scattered

(b) all colours are scattered away

(c) blue colour is scattered the most

(d) red colour is scattered the most

Correct Answer: (a) light is least scattered

Explanation: At noon, the sun is directly overhead. Sunlight travels the **shortest path** through the atmosphere. Very little scattering occurs -- all colours reach our eyes roughly equally. Hence the sun appears **white** (mixture of all colours). At sunrise/sunset, the path is much longer, so blue is scattered away and only red/orange remain.

Tip / Remember: Short path (noon) -> least scattering -> white sun. Long path (horizon) -> blue scattered -> red/orange sun.

Q5. Which phenomena of light are involved in the formation of a rainbow?

(a) Reflection, refraction and dispersion

(b) Refraction, dispersion and total internal reflection

(c) Refraction, dispersion and internal reflection

(d) Dispersion, scattering and total internal reflection

Correct Answer: (c) Refraction, dispersion and internal reflection

Explanation: A rainbow forms when sunlight interacts with water droplets: (1) **Refraction** -- light bends as it enters the water droplet; (2) **Dispersion** -- white light splits into VIBGYOR colours inside the droplet; (3) **Internal Reflection** -- light reflects off the back of the droplet (note: it is internal reflection, NOT total internal reflection -- the angle is not always at critical angle); (4) **Refraction again** -- as the light exits the droplet. Option (c) is correct. Option (b) says "total internal reflection" which is not precise.

Tip / Remember: Rainbow = Refraction (in) + Dispersion + Internal Reflection + Refraction (out).

Q6. Twinkling of stars is due to atmospheric

(a) dispersion by water droplets

(b) refraction by layers of varying refractive indices

(c) scattering by dust particles

(d) internal reflection by clouds

Correct Answer: (b) refraction by layers of varying refractive indices

Explanation: Stars are point sources at very large distances. Their light passes through multiple atmospheric layers, each with a slightly different temperature, pressure, and hence refractive index. These layers keep changing (due to turbulence), so the refractive index at any point keeps changing. This causes the apparent position and intensity of the star to shift rapidly -- we perceive this as **twinkling**. **Planets do not twinkle** because they are much closer and appear as extended (disc-like) sources -- variations average out across the disc.

Tip / Remember: Stars twinkle (point sources). Planets do NOT twinkle (extended disc sources -- variations cancel out).

Q7. The clear sky appears blue because

(a) blue light gets absorbed in the atmosphere

(b) ultraviolet radiations are absorbed

(c) violet and blue lights get scattered more than all other colours

(d) light of all other colours is scattered more than violet and blue

Correct Answer: (c) violet and blue lights get scattered more than all other colours

Explanation: By Rayleigh scattering, scattering is inversely proportional to the **4th power** of wavelength (scattering ~ 1/lambda^4). Shorter wavelengths (violet, blue) are scattered the most. Although violet is scattered MORE than blue, our eyes are more sensitive to blue, and some violet is absorbed by the atmosphere, so the sky appears **blue**. Option (c) is the most correct among the given options.

Tip / Remember: Violet is scattered even more than blue, but we see BLUE sky because our eyes are more sensitive to blue.

Q8. Which statement is correct regarding the propagation of light of different colours of white light in air?

(a) Red light moves fastest

(b) Blue light moves faster than green light

(c) All the colours move with the same speed

(d) Yellow moves at mean speed of red and violet

Correct Answer: (c) All the colours of the white light move with the same speed

Explanation: In **air (or vacuum)**, ALL colours of light travel at the same speed: $c = 3 \times 10^8$ m/s. Different speeds of different colours occur only in **denser media** (like glass or water), which is what causes dispersion in a prism. In air, there is no dispersion -- all colours have the same speed.

Tip / Remember: Different speeds -> different media (glass, water). In AIR/VACUUM: all colours same speed.

Q9. Danger signals at the top of tall buildings are red. These can be easily seen from a distance because red light

(a) is scattered the most by smoke or fog

(b) is scattered the least by smoke or fog

(c) is absorbed the most by smoke or fog

(d) moves fastest in air

Correct Answer: (b) is scattered the least by smoke or fog

Explanation: Red light has the **longest wavelength** among visible colours. By Rayleigh scattering, longer wavelength -> LESS scattering. So red light is scattered the LEAST by fog, smoke, or dust particles. It can penetrate these obstacles and travel farther without being deflected. This is why danger signals, traffic lights, and aviation lights use red.

Tip / Remember: Red = longest wavelength = least scattered = travels farthest through fog/smoke.

Q10. Which phenomenon contributes significantly to the reddish appearance of the sun at sunrise or sunset?

(a) Dispersion

(b) Scattering

(c) Total internal reflection

(d) Reflection from earth

Correct Answer: (b) Scattering of light

Explanation: At sunrise or sunset, sunlight travels through a much **thicker layer of atmosphere** to reach our eyes (compared to noon). During this long journey, **blue and shorter wavelength light is scattered away** in many directions. Only the **longer wavelengths (red and orange)** manage to travel through and reach our eyes. Hence the sun and sky appear reddish/orange at sunrise/sunset. This is the phenomenon of **scattering**, not dispersion.

Tip / Remember: Reddish sunrise/sunset = SCATTERING (blue scattered away, red remains). Do NOT say dispersion.

Q11. The bluish colour of water in the deep sea is due to

(a) presence of algae and other plants

(b) reflection of sky in water

(c) scattering of light

(d) absorption of light by the sea

Correct Answer: (c) scattering of light

Explanation: The blue colour of deep sea water is due to **scattering of sunlight by water molecules**. Similar to how the sky appears blue, the water molecules scatter shorter wavelengths (blue) more. This makes the deep sea appear bluish. (Note: shallow coastal water may appear green due to algae/plankton, but deep sea blue = scattering.)

Tip / Remember: Blue sea = scattering by water molecules. Blue sky = scattering by air molecules. Both: same principle.

Q12. When light rays enter the eye, most of the refraction occurs at the

(a) crystalline lens

(b) outer surface of the cornea

(c) iris

(d) pupil

Correct Answer: (b) outer surface of the cornea

Explanation: When light enters the eye from air, the first surface it hits is the **outer surface of the cornea**. The refractive index difference between air (n~1) and cornea/aqueous humour (n~1.34) is large, causing most of the bending (about 2/3 of total refraction). The crystalline lens provides additional fine-tuning refraction but contributes less overall. The iris and pupil are apertures, not refracting surfaces.

Tip / Remember: Cornea does MOST refraction (~67%). Lens provides fine adjustment for accommodation.

Q13. The focal length of the eye lens INCREASES when eye muscles

(a) are relaxed and lens becomes thinner

(b) contract and lens becomes thicker

(c) are relaxed and lens becomes thicker

(d) contract and lens becomes thinner

Correct Answer: (a) are relaxed and lens becomes thinner

Explanation: When the **ciliary muscles RELAX**, the tension on the lens increases (via suspensory ligaments), causing the lens to become **thin and flat**. A thinner, flatter lens has a **greater (longer) focal length** -- this allows distant objects to be focused on the retina. Conversely, when muscles CONTRACT, the lens becomes thicker/more curved, reducing the focal length for viewing near objects.

Tip / Remember: Relax muscles -> thin lens -> longer focal length -> far vision. Contract -> thick -> short f -> near vision.

Q14. Which of the following statements is correct?

(a) A person with myopia can see distant objects clearly

(b) A person with hypermetropia can see nearby objects clearly

(c) A person with myopia can see nearby objects clearly

(d) A person with hypermetropia cannot see distant objects clearly

Correct Answer: (c) A person with myopia can see nearby objects clearly

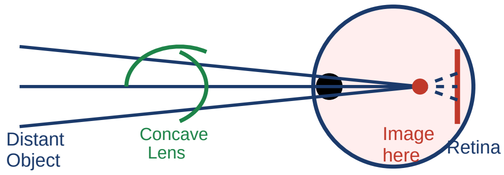
Explanation: Key facts: **Myopia (near-sightedness)**: Can see NEAR objects clearly; CANNOT see distant objects clearly. **Hypermetropia (far-sightedness)**: Can see DISTANT objects clearly; CANNOT see NEAR objects clearly. So option (c) is correct: "A person with myopia can see nearby objects clearly." Options (a), (b), (d) are all incorrect.

Tip / Remember: My(opia) = My nearby is clear. Hyper = far away is fine. Remember: Myo = Near; Hyper = Far.

SECTION 7 -- SHORT ANSWER QUESTIONS: SOLVED

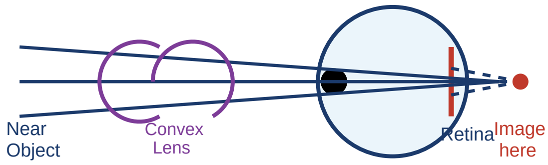
Q15. Draw ray diagrams each showing (i) myopic eye and (ii) hypermetropic eye.

(i) MYOPIA (Near-sightedness): Image forms IN FRONT of retina



Correction: CONCAVE lens diverges rays -> image shifts back to retina

(ii) HYPERMETROPIA (Far-sightedness): Image forms BEHIND retina



Correction: CONVEX lens converges rays -> image pulled to retina

Answer:

(i) Myopic Eye: The eyeball is elongated (too long). Light from a distant object converges to a point IN FRONT of the retina. The image on the retina is blurred. Far point is closer than infinity. Correction: Concave (diverging) lens shifts image back to the retina.

(ii) Hypermetropic Eye: The eyeball is too short (or lens too flat). Light from a near object would converge to a point BEHIND the retina. The image on the retina is blurred. Near point is farther than 25 cm. Correction: Convex (converging) lens brings image forward to retina.

Q16. A student sitting at the back of the classroom cannot read clearly the letters written on the blackboard. What advice will a doctor give to her? Draw ray diagram for correction.

Answer:

The student can see nearby (textbook) but not distant objects (blackboard). This is **MYOPIA (near-sightedness)**. The doctor will advise her to wear **spectacles with CONCAVE (diverging) lenses** of appropriate power.

How it works: A concave lens diverges the light rays before they enter the eye. The eye then converges these diverging rays to form the image exactly ON the retina. The power of the concave lens needed = -1/(far point in metres). For example, if her far point is 1 m, then P = -1 D.

[See ray diagram in Q15(i) for the uncorrected and corrected myopic eye diagrams above]

Q17. How are we able to see nearby and also the distant objects clearly?

Answer -- Power of Accommodation:

The human eye can see both nearby and distant objects clearly because of a property called the **POWER OF ACCOMMODATION** -- the ability of the eye lens to change its focal length by changing its curvature.

Seeing distant objects: The ciliary muscles RELAX. The lens becomes THIN and FLAT, increasing focal length. Light from the distant object (effectively parallel rays) is focused exactly on the retina.

Seeing nearby objects: The ciliary muscles CONTRACT. The lens becomes THICK and MORE CURVED, decreasing focal length. Diverging rays from the near object are now focused on the retina.

The minimum distance at which the eye can see clearly = **Near Point = 25 cm** (normal adult). The maximum distance = **Far Point = infinity** (normal eye).

Q18. A person needs a lens of power -4.5 D for correction of her vision. (a) What defect? (b) Focal length? (c) Nature of lens?

Answer:

(a) Defect: The power is NEGATIVE (-4.5 D), which means a CONCAVE (diverging) lens is needed. This corrects **MYOPIA (Near-sightedness / Short-sightedness)**.

(b) Focal Length: $f = 1/P = 1/(-4.5) = -2/9$ m = **-0.22 m (approximately -22 cm)**.

(c) Nature of Lens: The negative focal length confirms it is a **CONCAVE (diverging) lens**.

Additional info: Her far point = |f| = 22 cm. She cannot see objects beyond 22 cm clearly without glasses.

Q19. How will you use two identical prisms so that a narrow beam of white light incident on one prism emerges out of the second prism as white light? Draw the diagram.

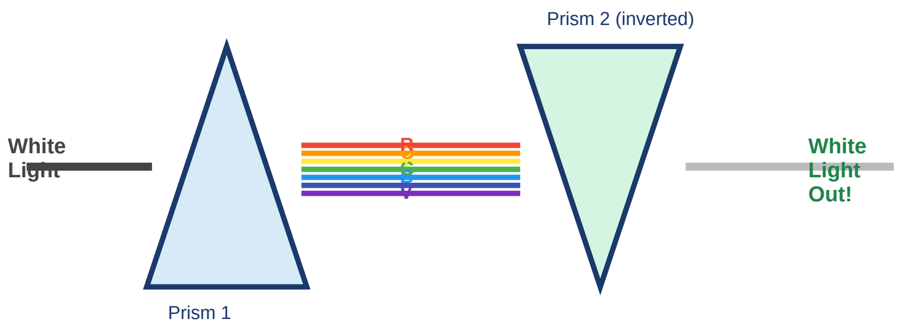


Fig. 11.3 -- Two Prisms: Dispersion + Recombination -> White Light

Answer:

Place the second prism in an **inverted position** (upside down) with respect to the first prism. When white light enters the first prism: it undergoes dispersion and splits into VIBGYOR. When this dispersed spectrum enters the second (inverted) prism: each colour is refracted back by the same amount but in the opposite direction. All colours recombine to give back **white light** at the exit.

This demonstration (due to Newton) proves that white light is a mixture of all colours, and that dispersion is reversible.

Q20. Draw a ray diagram showing dispersion through a prism when a narrow beam of white light is incident on one of its refracting surfaces. Also indicate the order of colours.

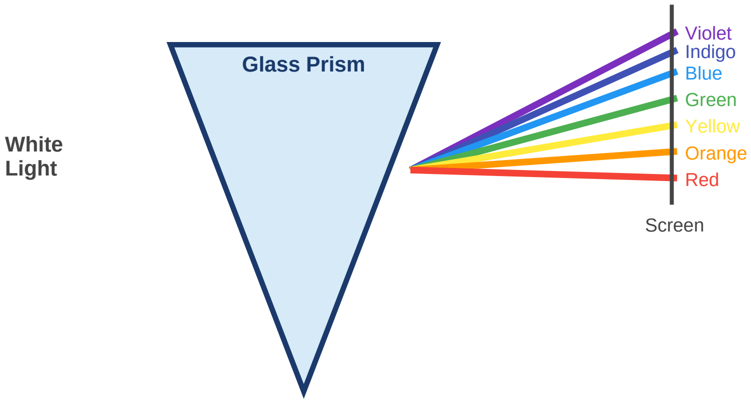


Fig. 11.2 -- Dispersion of White Light Through a Glass Prism (VIBGYOR)

Answer:

When a narrow beam of white light passes through a triangular glass prism, it undergoes **DISPERSION** -- splitting into its constituent colours.

Order from top (least deviated to most deviated): Red (R) -- Orange (O) -- Yellow (Y) -- Green (G) -- Blue (B) -- Indigo (I) -- Violet (V).

Why? Different colours have different wavelengths, so they travel at different speeds in glass, and hence bend by different amounts. Violet (shortest wavelength) bends the MOST; Red (longest wavelength) bends the LEAST.

The sequence VIBGYOR is from the most deviated (Violet at bottom of spectrum) to least deviated (Red at top) -- so from TOP: Red is the first colour.

Q21. Is the position of a star as seen by us its true position? Justify your answer.

Answer: No, it is NOT the true position.

The position of a star as seen by us is the **APPARENT position**, not the true position. This is due to **ATMOSPHERIC REFRACTION**.

Starlight travels from outer space and enters our atmosphere. The atmosphere has layers of gradually increasing density (and refractive index) from top to bottom. As light passes from a rarer layer to a denser layer, it bends TOWARDS the normal -- i.e., bends towards the Earth.

As a result, the star appears to be at a position slightly HIGHER and SHIFTED from its actual position. The bending is continuous as the light passes through multiple layers. When we extend the final ray back, it points to an apparent position different from the real one.

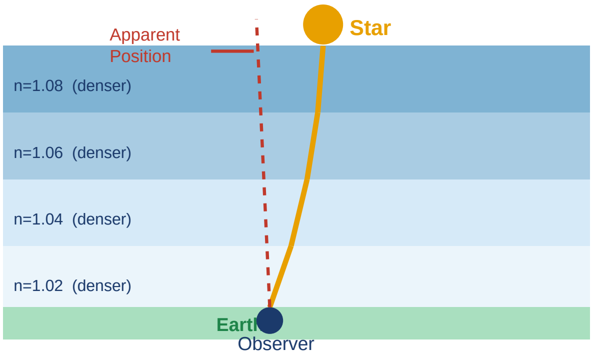


Fig. 11.6 -- Star Twinkling due to Atmospheric Refraction

Q22. Why do we see a rainbow in the sky only after rainfall?

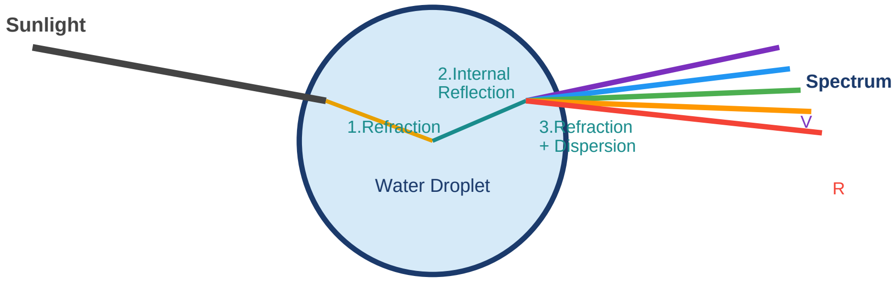


Fig. 11.4 -- Rainbow Formation: Refraction + Internal Reflection + Dispersion

Answer:

A rainbow is seen after rainfall because the air is filled with millions of tiny **water droplets** that act like small prisms. The formation involves three steps:

(1) **Refraction (entering droplet):** Sunlight entering a water droplet bends (refracts) at the air-water interface.

(2) **Dispersion:** White sunlight splits into its constituent colours (VIBGYOR) inside the droplet, since different colours refract by different amounts.

(3) **Internal Reflection:** The dispersed light internally reflects off the back of the water droplet.

(4) **Refraction (exiting droplet):** The light refracts again as it exits, further separating the colours.

The rainbow is seen in the direction OPPOSITE to the sun (observer has sun behind them). Violet is at the inner arc, Red at the outer arc.

Q23. Why is the colour of the clear sky blue?

Answer:

The clear sky appears blue due to **SCATTERING OF SUNLIGHT** by atmospheric molecules (mainly nitrogen and oxygen molecules).

White sunlight contains all colours (wavelengths). When it enters the atmosphere, molecules scatter different colours by different amounts. Scattering is proportional to $1/\lambda^4$ (Rayleigh scattering law), where lambda is wavelength.

Shorter wavelengths (violet and blue) are scattered much more than longer wavelengths (red, orange, yellow). Although violet is scattered most, our eyes are more sensitive to blue, and some violet is absorbed by the atmosphere. So the sky appears **BLUE** when we look in any direction other than directly at the sun.

Q24. What is the difference in colours of the Sun observed during sunrise/sunset and noon? Give explanation for each.

Answer:

During Sunrise/Sunset: The Sun appears **REDDISH or ORANGE**. At these times, the Sun is near the horizon, so sunlight must travel through a much THICKER layer of atmosphere to reach our eyes. During this long journey, most of the blue, violet, and other short-wavelength light is scattered away in different directions. Only the longer wavelengths -- **red and orange** -- reach us, making the Sun look reddish.

During Noon: The Sun appears **WHITE** (or slightly yellowish). At noon, the Sun is directly overhead, so sunlight travels through the minimum thickness of atmosphere. Very little scattering occurs, and all colours reach our eyes roughly equally. The combination of all colours gives us **white light**.

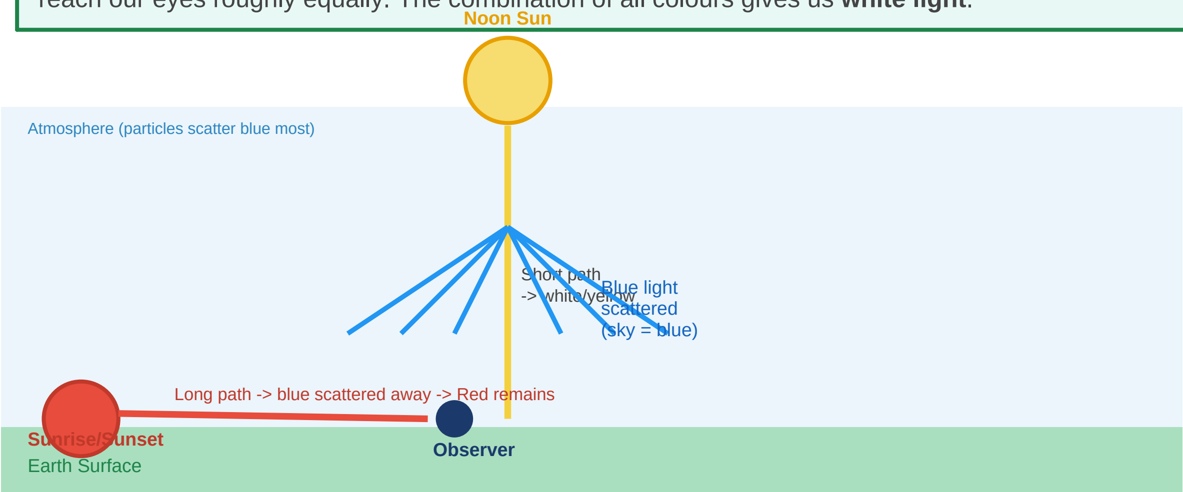


Fig. 11.5 -- Scattering of Light: Blue Sky & Reddish Sunrise/Sunset

SECTION 8 -- LONG ANSWER QUESTIONS: SOLVED

Q25. Explain the structure and functioning of the Human eye. How are we able to see nearby as well as distant objects?

STRUCTURE OF THE HUMAN EYE

The human eye is a natural optical instrument roughly spherical in shape (~2.3 cm diameter). Major parts:

1. Cornea: The transparent, curved front surface. Most refraction (about 67%) occurs here as light enters from air.

2. Iris: Pigmented muscular ring behind the cornea. Controls the size of the pupil to regulate light entering the eye.

3. Pupil: The dark central aperture of the iris. In bright light: pupil contracts; in dim light: pupil dilates.

4. Crystalline Lens (Eye Lens): A flexible biconvex lens made of transparent fibres. Its curvature is changed by ciliary muscles to focus on objects at different distances.

5. Ciliary Muscles: Attach to the lens via suspensory ligaments. Control the shape (and hence focal length) of the lens.

6. Aqueous Humour: Watery fluid between cornea and lens.

7. Vitreous Humour: Jelly-like fluid filling the main cavity behind the lens, maintaining the eye's shape.

8. Retina: The inner light-sensitive layer lining the back of the eye. Contains photoreceptors: rods (dim light) and cones (colour vision).

9. Optic Nerve: Carries visual signals from the retina to the visual cortex of the brain.

FUNCTIONING -- HOW THE EYE FORMS AN IMAGE

Light from an object enters the eye through the cornea (main refraction), passes through the aqueous humour, through the pupil, and is further refracted and focused by the lens. A real, inverted, diminished image forms on the retina. The retina converts light to electrical signals sent via the optic nerve to the brain, which interprets it as an upright image.

POWER OF ACCOMMODATION -- Seeing Near and Far:

The eye can see clearly at different distances due to its POWER OF ACCOMMODATION -- the ability to change the focal length of the lens:

Distant objects (>= far point = infinity for normal eye): Ciliary muscles RELAX -> suspensory ligaments tighten -> lens becomes THIN (less curved) -> focal length INCREASES -> parallel rays from distant object focused on retina.

Near objects (near point = 25 cm for normal adult): Ciliary muscles CONTRACT -> ligaments loosen -> lens becomes THICK (more curved) -> focal length DECREASES -> diverging rays from near object focused on retina.

This continuous adjustment of lens curvature = **ACCOMMODATION**.

Q26. When do we consider a person to be myopic or hypermetropic? Explain using diagrams how the defects associated with myopic and hypermetropic eye can be corrected.

MYOPIA (Near-sightedness)

When: A person is considered myopic when they CANNOT see distant objects clearly but CAN see nearby objects clearly. The far point is closer than infinity.

Cause: (i) Eyeball is too long (elongated), OR (ii) The eye lens is too curved (short focal length). Result: Image of distant object forms IN FRONT of the retina.

Correction: A CONCAVE (diverging) lens of appropriate power. The concave lens diverges the rays BEFORE they enter the eye, effectively shifting the image of distant objects to fall on the retina. Power needed: P = -1/d, where d = far point in metres (negative = concave lens).

HYPERMETROPIA (Far-sightedness)

When: A person is considered hypermetropic when they CANNOT see nearby objects clearly but CAN see distant objects clearly. The near point is farther than 25 cm.

Cause: (i) Eyeball is too short, OR (ii) Eye lens is too flat (long focal length). Result: Image of near object would form BEHIND the retina.

Correction: A CONVEX (converging) lens of appropriate power. The convex lens converges the rays BEFORE they enter the eye, making diverging rays from a near object appear to come from the far point of the eye, allowing the eye lens to focus it on the retina. Power needed: positive (P = 1/f, where f > 0).

[See diagrams for both defects and corrections in Q15 section above]

Q27. Explain the refraction of light through a triangular glass prism using a labelled ray diagram. Hence define the angle of deviation.

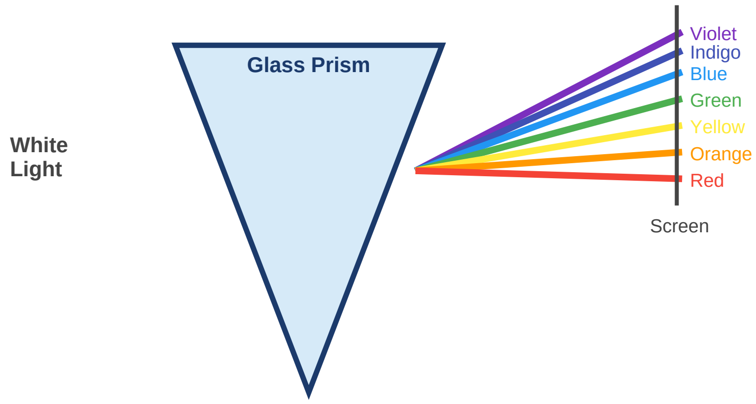


Fig. 11.2 -- Dispersion of White Light Through a Glass Prism (VIBGYOR)

Refraction Through a Triangular Prism

A triangular glass prism has two refracting surfaces. When a ray of light PQ strikes the first face AB:

Step 1: The ray PQ is incident on face AB at point E. It enters the denser glass medium, refracting towards the normal (bending towards the base BC).

Step 2: The refracted ray EF travels inside the prism to the second face AC, striking it at point F. It now exits into the rarer air medium, refracting away from the normal (again bending towards base BC).

Step 3: The emergent ray FS travels in a new direction.

ANGLE OF DEVIATION (D): The angle between the original incident ray (PQ extended) and the final emergent ray (FS) is called the **ANGLE OF DEVIATION**. It measures how much the prism has "deviated" the light from its original path. For white light, each colour has a different angle of deviation: Violet is deviated the MOST (largest D), Red is deviated the LEAST (smallest D).

Q28. How can we explain the reddish appearance of sun at sunrise or sunset? Why does it not appear red at noon?

Reddish Appearance at Sunrise/Sunset

At sunrise or sunset, the Sun is near the horizon. The sunlight has to travel through a MUCH LONGER PATH through the Earth's dense atmosphere to reach our eyes compared to midday.

During this long journey through the atmosphere, the shorter wavelength light (violet, blue, indigo) undergoes **Rayleigh scattering** more strongly and is scattered away in many directions. By the time the light reaches us, most of the blue and violet light has been removed.

Only the longer wavelength light -- **RED and ORANGE** -- which is scattered the least, manages to travel through the thick atmosphere and reach our eyes. Hence the Sun appears reddish/orange at sunrise and sunset.

Why NOT red at noon: At noon, the Sun is almost directly overhead. Sunlight travels through the SHORTEST possible path through the atmosphere. Scattering is minimal for all colours. All colours reach our eyes with nearly equal intensity, so the Sun appears **WHITE** (or slightly yellowish) at noon.

Q29. Explain the phenomenon of dispersion of white light through a glass prism, using suitable ray diagram.

Dispersion of White Light

Definition: Dispersion is the splitting of white light into its constituent colours (VIBGYOR) when it passes through a prism or other dispersive medium.

Cause: White light is a mixture of 7 colours: Violet, Indigo, Blue, Green, Yellow, Orange, Red. Each colour has a different wavelength and hence a different refractive index in glass. Different refractive indices mean different angles of refraction at the two prism surfaces.

Order of refraction (deviation): Violet light (shortest wavelength) has the highest refractive index in glass -> bends the MOST. Red light (longest wavelength) has the lowest refractive index -> bends the LEAST.

Result: After passing through the prism, white light fans out into a band of seven colours called the **SPECTRUM**. The order from least deviated to most deviated: R -- O -- Y -- G -- B -- I -- V (Red at top, Violet at bottom).

Historical note: Sir Isaac Newton first demonstrated in 1666 that a prism disperses white light into a spectrum, and that these colours could be recombined by a second inverted prism to give white light again.

[See dispersion ray diagram in Q20 section above]

Q30. How does refraction take place in the atmosphere? Why do stars twinkle but not the planets?

Atmospheric Refraction

The Earth's atmosphere consists of multiple layers of air with varying temperatures, pressures, and densities. As altitude decreases, density increases. Higher density means higher refractive index.

When light from a star (or any celestial body) travels from outer space into Earth's atmosphere, it continuously passes from rarer to denser layers. At each transition, it bends TOWARDS the normal (towards Earth). This continuous bending makes starlight follow a curved path, and the apparent position of the star is HIGHER than its true position.

WHY STARS TWINKLE: Stars are so far away that they appear as **point sources** of light. The atmospheric layers are in constant turbulent motion (due to temperature differences, winds, etc.). This continuously changes the refractive index of the layers the starlight passes through. As a result, the path, intensity, and apparent position of the star keep changing rapidly. We perceive these rapid fluctuations as **twinkling**.

WHY PLANETS DO NOT TWINKLE: Planets are much closer to Earth compared to stars. Due to their proximity, planets appear as **extended sources of light** (small discs). The atmosphere causes different portions of the disc to fluctuate, but these fluctuations AVERAGE OUT across the disc. The overall brightness remains nearly constant, so planets do NOT appear to twinkle -- they shine steadily.

[See atmospheric refraction diagram in Q21 section above]

SECTION 9 -- COMMON MISTAKES & EXAM TRAPS

Common Mistake: MCQ 1: Power Calculation for Myopia: Students use the near point (25 cm) instead of the far point to calculate power. For myopia: use the FAR POINT. P = -1/far_point_in_metres. The near point is used for hypermetropia correction.

Common Mistake: MCQ 3: Prism Orientation and Colour Order: Confusing which colour appears at the top when light exits the prism. When apex is at the top and light enters the left face: Red is LEAST deviated (appears at top), Violet MOST deviated (at bottom). Third from top = Blue = colour of sky. This orientation is case (ii).

Common Mistake: MCQ 5: Rainbow Phenomena: Writing "total internal reflection" instead of "internal reflection" for rainbow. The reflection inside a water droplet is INTERNAL REFLECTION, not necessarily TOTAL internal reflection. Option (c) is correct.

Common Mistake: MCQ 8: Speed of Light in Air: Thinking different colours travel at different speeds in AIR. ALL colours travel at the SAME speed (3x10^8 m/s) in air/vacuum. Speed differences occur only in denser media like glass, water.

Common Mistake: MCQ 13: Ciliary Muscles and Focal Length: Getting confused about which muscle state gives longer focal length. RELAX -> thin lens -> LONGER focal length (distant vision). CONTRACT -> thick lens -> SHORTER focal length (near vision).

Common Mistake: Q15/Q26: Mixing Up Myopia and Hypermetropia: Myopia: cannot see FAR; corrected by CONCAVE. Hypermetropia: cannot see NEAR; corrected by CONVEX. Mnemonic: "Myo = My nearby vision is fine."

Common Mistake: Q21: Stars Not at True Position: Many students say "Yes, we see the true position" -- this is WRONG. Atmospheric refraction bends starlight, so apparent position differs from true position. The star appears slightly HIGHER than its true position.

Common Mistake: Q28: Confusing Dispersion with Scattering: Saying "dispersion" causes the reddish sunrise/sunset is WRONG. It is SCATTERING (Rayleigh scattering) that causes reddish sunrise/sunset. Dispersion = splitting by prism. Scattering = redirection by particles.

Common Mistake: Q30: Planets and Twinkling: Saying "planets also twinkle" is wrong. Planets appear as EXTENDED SOURCES (discs) because they are much closer. Fluctuations in different parts of the disc cancel out, so planets shine steadily. Only POINT SOURCES (stars) twinkle.

EXAM TIPS AND MNEMONICS

Tip / Remember: Colour Order: VIBGYOR = Violet Indigo Blue Green Yellow Orange Red. Violet bends MOST, Red LEAST. Use "Vibrant Indians Buy Green Yoghurt On Roads."

Tip / Remember: Power Formula: P = 1/f. Concave lens: f < 0 -> P < 0. Convex lens: f > 0 -> P > 0.

Tip / Remember: Scattering Law: Scattering ~ 1/lambda^4. Smaller wavelength -> MUCH MORE scattering. Blue is ~5.5x more scattered than red.

Tip / Remember: Near/Far Point: Normal eye: Near = 25 cm (D), Far = infinity. For myopia: P = -1/far_point. For hypermetropia: use the near point for calculation.

Tip / Remember: Eye Accommodation: Relax = Far vision (thin lens, long f). Contract = Near vision (thick lens, short f). Think: "Relax to see the horizon; strain to read a book."

Tip / Remember: Rainbow Observer Position: Always have the SUN BEHIND you to see a rainbow. The rainbow arc is in the direction OPPOSITE to the sun.

Tip / Remember: Twinkling vs Planets: Stars TWINKLE (point sources). Planets STEADY (extended discs). "Stars are shy -- they twinkle. Planets are confident -- they shine steady."

Tip / Remember: Diagram Tips: In NCERT diagrams, always label: incident ray, refracted ray, emergent ray, angle of incidence, angle of refraction, normal, and angle of deviation.

SECTION 10 -- QUICK REVISION TABLE

Topic	Key Fact	Remember
Cornea	Does ~67% of eye refraction	Most refraction = cornea, not lens
Pupil	Controls amount of light entering	Iris muscle controls pupil size
Accommodation	Eye lens changes curvature	Ciliary muscles control lens shape
Near Point (normal)	25 cm	Also = Least Distance of Distinct Vision
Far Point (normal)	Infinity	Myopia: far point moves closer
Myopia correction	Concave lens; P = -1/d (negative)	d = far point in metres
Hypermetropia	Convex lens; positive power	Near point recedes beyond 25 cm
Dispersion	White -> VIBGYOR through prism	Violet bends most; Red least
Scattering law	~ 1/lambda^4 (Rayleigh)	Short wavelength scattered more
Blue sky	Blue light scattered by air molecules	Violet also scattered, but eyes less sensitive
Red sunrise/sunset	Long path; blue scattered away	Red least scattered; reaches us
White noon sun	Short path; least scattering	All colours reach us equally
Rainbow	Refraction + internal reflection + dispersion	Water droplets after rain; sun behind observer
Twinkling of stars	Atmospheric refraction -- changing layers	Planets do not twinkle (extended disc sources)
Speed of light in air	Same for all colours: 3x10^8 m/s	Different in denser media -> dispersion
Danger signals = Red	Least scattered -> travels farthest	Longest wavelength in visible spectrum
Angle of deviation	Angle between incident and emergent ray	Different for each colour; Violet has max D
Apparent star position	Higher than true position	Due to atmospheric refraction; bending towards Earth
Power of lens	P = 1/f (f in metres); unit = Dioptre (D)	Negative = concave; Positive = convex

MCQ ANSWER KEY GRID (Official NCERT Answers)

Q1	Q2	Q3	Q4	Q5	Q6	Q7
(b)	(a)	(b)	(a)	(c)	(b)	(c)

Q8	Q9	Q10	Q11	Q12	Q13	Q14
(c)	(b)	(b)	(c)	(b)	(a)	(c)