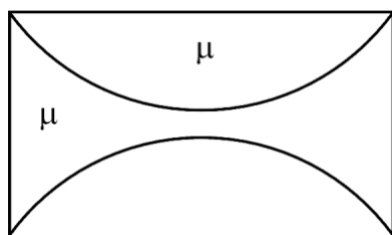


	INDIAN SCHOOL AL WADI AL KABIR	
Class: XII	Department: SCIENCE 2026– 27 SUBJECT: PHYSICS	Date: 12/10/2026
Worksheet No: 9 WITH ANSWERS	CHAPTER / UNIT: RAY OPTICS AND OPTICAL INSTRUMENTS	Note: A4 FILE FORMAT
CLASS & SEC:	NAME OF THE STUDENT:	ROLL NO.:

MULTIPLE CHOICE QUESTIONS:

- A concave lens of focal length 10 cm is cut into two identical plano-concave lenses. The focal length of each lens will be
 (A) 20 cm (B) 30 cm
 (C) 40 cm (D) 5 cm
 CBSE 2026 55/1/1 Q9
- A concave lens of focal length 40 cm is coaxially in contact with two convex lenses, each of focal length 20 cm, on each side. The focal length of the combination is
 (A) zero (B) 20/3 cm
 (C) -20/3 cm (D) 40/3 cm
 CBSE 2026 55/1/2 Q5
- Light from a small object in air falls on a spherical glass surface ($n = 1.5$) of radius of curvature R . A real image of the object will be formed if the object distance u is related to R as :
 (A) $u < R/2$ (B) $R/2 < u < R$
 (C) $R < u < 2R$ (D) $u > 2R$
 CBSE 2026 55/1/3 Q7
- A thin plano-convex lens and a thin equi-concave lens are kept coaxially in contact as shown in the figure. Assuming both the lenses are made of glass of refractive index μ , and R is the radius of curvature of each curved surface, the focal length of the combination is :
 CBSE 2026 55/3/1 Q4 · 55/3/2 Q12 · 55/3/3



- (A) $R/(\mu - 1)$ (B) $-R/(\mu - 1)$
 (C) $2R/(\mu - 1)$ (D) $-2R/(\mu - 1)$
- A telescope has an objective lens of focal length 144 cm and an eyepiece of focal length 6.0 cm. The magnifying power and the length of telescope tube will be respectively :
 (A) 24, 150 cm (B) 42, 138 cm
 (C) 24, 138 cm (D) 42, 150 cm
 CBSE 2026 55/3/1 Q6
- In which of the following, total internal reflection does **not** occur ?
 (A) Twinkling of stars (B) Brilliance of diamonds
 (C) Optical fibre (D) Reflecting prism
 CBSE 2026 55/3/1 Q7
- An equiconvex lens of focal length 15 cm is cut into two equal plano-convex halves. The focal length of each half will be :
 (A) 30 cm (B) 20 cm
 CBSE 2026 55/3/2 Q3

- (C) 15 cm (D) 7.5 cm
8. A plano-convex lens, made of glass ($n = 1.5$) has a curved surface whose radius is 40 cm. The image formed of an object is of the same size as that of the object. The distance of the object from the lens is :
CBSE 2026 55/3/2
- Q5
- (A) 40 cm (B) 80 cm
(C) 160 cm (D) 200 cm
9. A ray of monochromatic light travelling in air is incident on a glass slab and is partly reflected and partly refracted. Both the reflected and refracted lights will have :
CBSE 2026 55/3/3 Q2
- (A) same wavelength (B) same frequency
(C) same intensity (D) same speed
10. A ray of yellow light undergoes total internal reflection when it is incident at the interface of two media. This ray is successively replaced by the ray of blue, green and red lights. Which of the following statements is true if the angle of incidence is same in all cases ?
CBSE 2026 55/3/3 Q9
- (A) Total internal reflection occurs for blue light only.
(B) Total internal reflection occurs for red light only.
(C) Total internal reflection occurs for both green and blue lights.
(D) None of them will undergo total internal reflection.
11. The process that allows light to travel through a tube which is not straight is –
CBSE 2026 55(B) Q4
- (A) reflection of light (B) dispersion of light
(C) scattering of light (D) total internal reflection

ASSERTION - REASON BASED QUESTIONS

Direction: - In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as:

- (a) If both assertion and reason are true and reason is the correct explanation of assertion.
(b) If both assertion and reason are true but reason is not correct explanation of assertion.
(c) If assertion is true, but reason is false.
(d) If both assertion and reason are false.
12. **Assertion (A)** : When a convex lens made of glass is immersed in water, its converging power increases.
Reason (R) : The focal length of a lens depends only on the radii of curvature of its two faces.

CBSE 2026 55/4/1 Q15 · 55/4/2 Q16 · 55/4/3 Q13

13. **Assertion (A)** : When a ray of light enters from air into glass, frequency of light remains the same.
Reason (R) : The speed and wavelength of light both changes in glass. CBSE 2026 55(B) Q15

2-MARKS QUESTIONS

14. A ray of light in air is incident at angle i on a face of an equilateral glass prism and is refracted through the prism. As i is varied, it is observed that the ray undergoes minimum deviation, when the i is three-fourth of the angle of the prism. Calculate the speed of light in the prism.
CBSE 2026 55/2/1 Q19
15. A 5 cm long pencil is placed along the principal axis of a concave mirror of focal length 20 cm such that its nearest end is at a distance of 25 cm from the mirror. Calculate the length of the image of the pencil.
CBSE 2026 55/2/1 Q19 · 55/2/1 Q21 · 55/2/2 Q17 · 55/2/3
16. A ray of light is incident on the face of a triangular prism of refracting angle 60° and it just suffers total internal reflection at the other face. Find the angle of incidence for the ray if the refractive index of the material of the prism is $\sqrt{2}$.
CBSE 2026 55/2/2 Q19
17. A ray of light is incident at an angle $2A$ on one of the faces of a glass prism of refracting angle A . After

refraction from this face, the ray strikes the opposite face which is silvered. The reflected ray from this face retraces on its path. Trace the ray diagram and find the relation between the refractive index of material of prism and the angle of prism. CBSE 2026 55/2/3 Q21

18. Draw a labelled ray diagram of an astronomical telescope when final image is formed at infinity. Write the expression for its magnifying power. CBSE 2026 55/3/2 Q20

19. A small bulb is placed at the bottom of a tank, containing a transparent liquid of refractive index $\sqrt{2}$, to a depth of 1 m. Calculate the area of the surface of the liquid through which light from the bulb emerges. CBSE 2026 55/4/1 Q19

20. A concave mirror of radius of curvature 16 cm produces two-times enlarged real image of an object kept in front of it. Find the position of the object. CBSE 2026 55/4/2 Q19

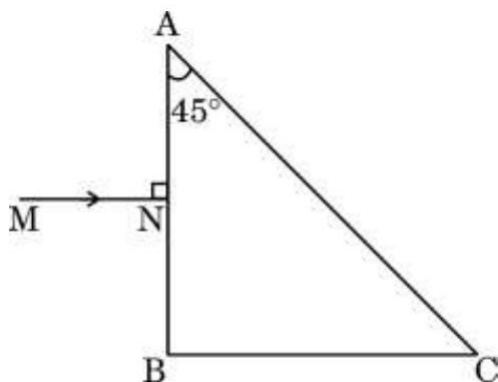
21. A convex lens of refractive index 1.5 has a focal length of 20 cm in air. Find its nature and focal length when it is immersed in a transparent liquid of refractive index 1.25. CBSE 2026 55/4/3 Q20

22. A tank is filled with a liquid to a height of 12.5 m. The apparent depth of a needle lying at the bottom of the tank is measured to be 9.0 m. Calculate the speed of light in the liquid. CBSE 2026 55/5/1 Q19

23. Two thin lenses of focal length f_1 and f_2 are placed in contact with each other coaxially. Prove that the focal length f of the combination is given by $f = f_1 f_2 / (f_1 + f_2)$. CBSE 2026 55/5/1 Q20

24. A point source, in air, is placed at a distance of 6 cm in front of a convex spherical surface ($n = 1.5$ and radius of curvature = 24 cm). Find the position and nature of the image formed. CBSE 2026 55/5/2 Q21

25. A ray of light MN is incident normally on the face corresponding with side AB of a prism with an isosceles right-angled triangular base ABC. Trace the path of the ray as it passes through the prism when the refractive index of the prism material is (i) $\sqrt{2}$, and (ii) $\sqrt{3}$. CBSE 2026 55/5/3 Q18



26. When monochromatic light is incident on a surface separating two media, the refracted and reflected light both have the same frequency as the incident frequency but the wavelength of refracted light is different. Explain why. CBSE 2026 55/5/3 Q19

27. (a) A ray of light travelling along the principal axis is incident on a spherical mirror and reflected back along the same path. Explain, why ?

(b) Write all the sign convention followed for a convex lens. CBSE 2026 55(B) Q18

28. A small object is placed in air in front of a convex glass surface ($n = 1.5$ and radius of curvature 20 cm) at a distance of 50 cm from it. Find the position and nature of the image. CBSE 2026 55(B) Q19

3-MARKS QUESTIONS

29. (a) Draw the ray diagram to show the image formation by a refracting telescope and write the expression for angular magnification for the telescope in normal adjustment.

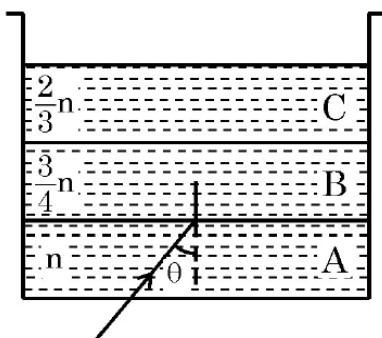
(b) Give two reasons to explain why a reflecting telescope is preferred over a refracting telescope.

CBSE 2026 55/1/1 Q27

30. (a) State the two conditions under which total internal reflection occurs.

(b) A transparent container contains layers of three immiscible transparent liquids A, B and C of refractive indices n , $(3/4)n$ and $(2/3)n$, respectively. A laser beam is incident at the interface between A and B at an angle θ as shown in figure. Prove that the beam does not enter region C at all for $\sin \theta \geq 2/3$.

CBSE 2026 55/1/1 Q28 · 55/1/2 Q23 · 55/1/3 Q24



31. Draw a labelled ray diagram showing the formation of image by a compound microscope when final image is formed at least distance of distinct vision. Derive an expression for its magnifying power for this case.

CBSE 2026 55/1/2 Q28

32. (a) Why does one prefer to view the image formed at infinity than that formed at near point in microscope/telescope ?

(b) Consider lenses L_1 , L_2 and L_3 as specified in the following table. Which of them will you select as objective and eyepiece for constructing best possible (i) telescope (ii) compound microscope? Give reason for your answer.

CBSE 2026 55/1/3 Q28

Lens	L_1	L_2	L_3
Power	6 D	3 D	10 D
Aperture	1 cm	8 cm	1 cm

33. A ray of light is travelling through a rectangular glass slab (refractive index $3/2$) and is incident on the horizontal glass-air surface at the critical angle for the two media. The slab is then brought in contact with water (refractive index $4/3$) such that a thin horizontal layer of water is formed on the surface of the slab. Find the angle at which the ray will emerge into air from the water-air surface.

CBSE 2026 55/3/1 Q26

34. Define the term 'critical angle'. A small bulb is placed at the bottom of a tank containing a liquid of refractive index μ at a depth H . It is observed that the light emerges from a circular area of radius r of the surface. Obtain the expression for r in terms of H and μ .

CBSE 2026 55/3/2 Q23

35. A ray of light is incident at angle of 45° on one face of a prism with an equilateral triangular base. If it passes symmetrically through the prism, find the :

(a) angle of minimum deviation for the prism, and

(b) refractive index of the material of the prism.

CBSE 2026 55/3/3 Q23

CASE STUDY QUESTIONS

36. In an experiment with convex lens of focal length f , the screen is fixed at a distance D from the object. A student slowly moves the lens away from the object towards the screen and finds that she is able to form sharp image of the object for two positions of the lens. The distance between these two positions of the lens is d .

CBSE 2026 55/2/1 Q30 · 55/2/2 Q29 · 55/2/3 Q30

- (i) The value of d is
 (A) $\sqrt{[D(D - 4f)]}$ (B) $\sqrt{[D(D - 2f)]}$
 (C) $2\sqrt{(Df)}$ (D) $\sqrt{[D(D - f)]}$
- (ii) Compared to the size of the object, the images formed in the two positions of the lens are respectively
 (A) reduced, enlarged (B) reduced, reduced
 (C) enlarged, enlarged (D) enlarged, reduced
- (iii) If the distance between object and screen is 80.00 cm and the lens forms sharp images at two positions separated by 20.00 cm., the focal length of convex lens is
 (A) 15.50 cm (B) 18.75 cm
 (C) 20.50 cm (D) 22.75 cm
- (iv) Consider a convex lens of focal length 15 cms. For which of the following values of object-screen distance, two positions of the object can be found to obtain sharp image on the screen?
 (A) 45 cm (B) 50 cm
 (C) 55 cm (D) 65 cm

OR

- (iv) A thin convex lens of focal length 10 cm and another thin lens of focal length ' f ' are placed coaxially in contact. If the power of their combination is $10/3$ D, the value of ' f ' is
 (A) -15 cm (B) -10 cm
 (C) -20 cm (D) -30 cm

37. An astronomical telescope consists of two converging lenses. One of them of large aperture and large focal length is called objective lens and the other one, of smaller focal length and smaller aperture is called the eyepiece. It is used to see distant objects which are not seen clearly with naked eyes. The image formed by the objective lens acts as an object for the eyepiece and the final image produced by the eyepiece is magnified.
 CBSE 2026 55/4/1 Q30 · 55/4/2 Q29 · 55/4/3 Q29

- (i) The images formed by the objective lens and the eyepiece are respectively :
 (A) virtual, real (B) real, virtual
 (C) virtual, virtual (D) real, real
- (ii) The magnification produced by the telescope does not depend upon the :
 (A) colour of light (B) focal length of objective lens
 (C) focal length of eyepiece (D) apertures of objective lens and eyepiece
- (iii) Which of the following statements is not correct for this telescope ?
 (A) The focal length of objective lens (f_o) is larger than the focal length of eyepiece (f_e).

- (B) Its magnifying power can be increased by increasing the focal length of objective lens (f_o).
- (C) The distance between two lenses is more than ($f_o + f_e$).
- (D) The magnifying power can be decreased by increasing the focal length of eyepiece.

- (iv) (a) An astronomical telescope has objective lens and eyepiece of focal lengths 80 cm and 4 cm respectively. To view the image in normal adjustment, the lenses must be separated by a distance of :
- | | |
|-----------|------------|
| (A) 84 cm | (B) 76 cm |
| (C) 20 cm | (D) 320 cm |

OR

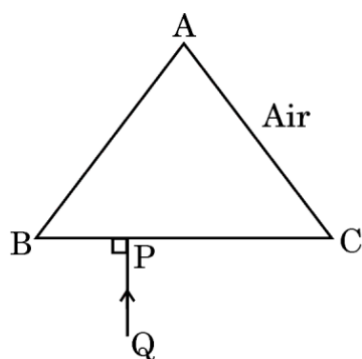
- (iv) (b) Consider the telescope described in question (iv) (a). Its magnifying power in normal adjustment will be:
- | | |
|---------|--------|
| (A) 320 | (B) 84 |
| (C) 76 | (D) 20 |

5-MARKS QUESTIONS

38. (a) Using the relation for refraction at a curved spherical surface, derive the expression for lens maker's formula.
- (b) Three lenses L_1 , L_2 and L_3 , each of focal length 40 cm, are placed coaxially. The distance between L_1 and L_2 and between L_2 and L_3 are 120 cm and 20 cm respectively. An object is kept at a distance of 80 cm to the left of lens L_1 . Find the distance of the final image formed from the object.
39. (a) Draw a ray diagram to show the image formation by a concave mirror when the object is kept between its focus and the centre of curvature. Using this diagram, derive the mirror formula.
- (b) A concave mirror produces a two times magnified virtual image of an object kept 10 cm in front of it. Calculate the focal length of the mirror.
- CBSE 2026 55/1/1 Q32 · 55/1/2 Q33 · 55/1/3 Q31
40. (a) Draw a labelled ray diagram of a refracting telescope when it forms image of a distant object at infinity. Derive expression for its magnifying power.
- (b) (i) In a telescope the objective has much larger aperture than the eye piece. Why ?
(ii) Write two advantages of reflecting telescope over refracting telescope.
- CBSE 2026 55/2/1 Q31 · 55/2/2 Q32 · 55/2/3 Q33 .
41. (a) (i) A point object is kept in front of a convex spherical surface of radius of curvature R . Draw the ray diagram to show the formation of image and derive the relation between the object and image distance (u and v) in terms of refractive index n of the medium and R .
- (ii) A convex lens of focal length of 20 cm is used to form the image of an object placed 30 cm away from the lens. Find the position and nature of the image formed.
42. (i) Define refractive index of a medium in terms of speed of light.
- (ii) Derive the relation for the refractive index (μ) of a prism in terms of angle of minimum deviation (δ_m) and angle of prism (A).
- (iii) A ray of light QP is incident normally on the face BC of a triangular prism ABC of refractive index 1.5 kept in air, as shown in the figure. Trace the path of the ray as it passes through the prism and

give relevant explanation.

CBSE 2026 55/4/1 Q31 · 55/4/2 Q32 · 55/4/3 Q33



43. (i) With the help of a ray diagram, describe the construction and working of a compound microscope.

(ii) (I) The real image of an object placed between f and $2f$ from a convex lens can be seen on a screen placed at the image location. If the screen is removed, is the image still there? Explain.

(II) Plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances? Explain.

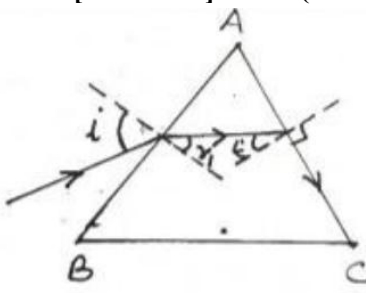
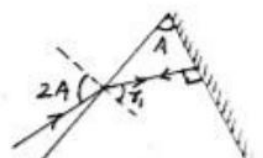
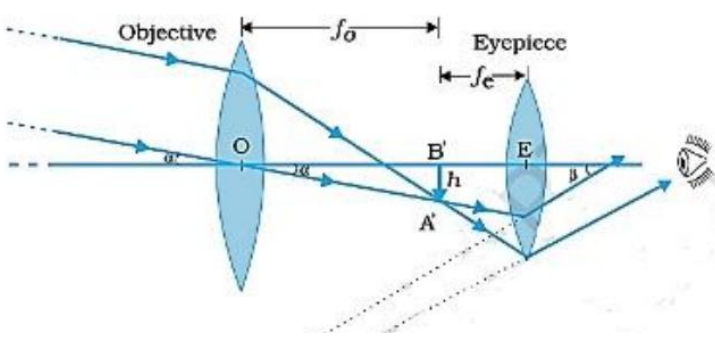
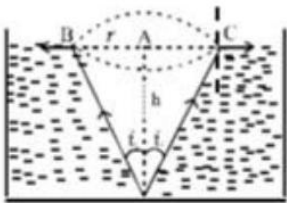
CBSE 2026 55/5/1 Q33 · 55/5/2 Q32 · 55/5/3 Q31

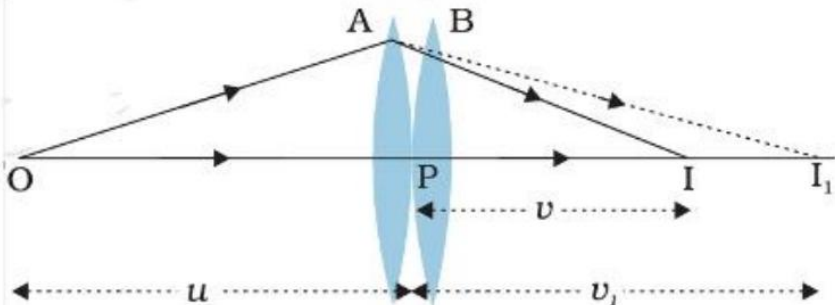
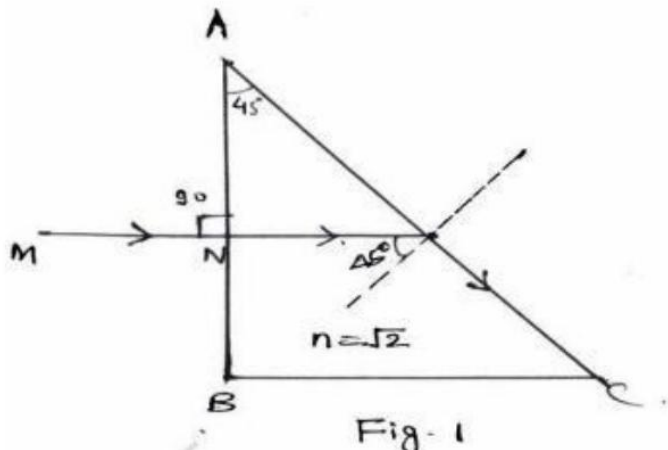
44. (a) Briefly explain the working of a reflecting type telescope. Write its two advantages over a refracting telescope.

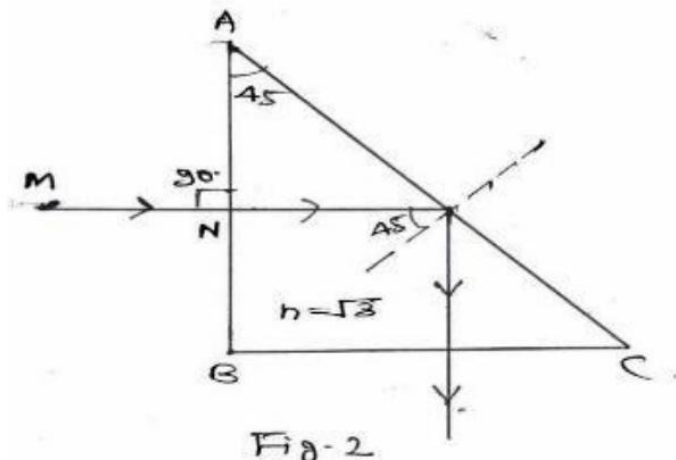
(b) A telescope consists of two lenses of focal length 125 cm and 5 cm. Find its magnifying power when final image is at (i) infinity (ii) at a distance of 25 cm from eye.

CBSE 2026 55(B) Q33

ANSWER KEY	
1	(A) 20 cm
2	(D) $40/3$ cm
3	(D) $u > 2R$
4	(B) $-R/(\mu - 1)$
5	(A) 24, 150 cm
6	(A) Twinkling of stars
7	(A) 30 cm
8	(C) 160 cm
9	(B) same frequency
10	(C) Total internal reflection occurs for both green and blue lights.
11	(D) total internal reflection of light
12	(d) Both Assertion (A) and Reason (R) are false.
13	(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).
14	Angle of incidence, $i = \frac{3}{4}A = \frac{3}{4} \times 60^\circ = 45^\circ$ At minimum deviation, $r = A/2 = 30^\circ$ $n = \sin i / \sin r = \sin 45^\circ / \sin 30^\circ = \sqrt{2}$

	$n = c/v \Rightarrow v = (3/\sqrt{2}) \times 10^8 \text{ m/s} = \mathbf{2.12 \times 10^8 \text{ m/s}}$
15	For the near end of the pencil: $1/v_1 = 1/f - 1/u_1 = 1/(-20) - 1/(-25) \Rightarrow v_1 = -100 \text{ cm}$ For the far end of the pencil: $1/v_2 = 1/(-20) - 1/(-30) \Rightarrow v_2 = -60 \text{ cm}$ Length of the image, $L = v_1 - v_2 = \mathbf{40 \text{ cm}}$
16	At the second face the ray just suffers total internal reflection, so $r_2 = i_c$. $\sin i_c = 1/n = 1/\sqrt{2} \Rightarrow i_c = 45^\circ$ $r_1 + r_2 = A \Rightarrow r_1 = A - i_c = 60^\circ - 45^\circ = 15^\circ$ $\sin i = n \sin r_1 = \sqrt{2} \sin 15^\circ$ $\mathbf{i = \sin^{-1}[\sqrt{2} \sin 15^\circ] = \sin^{-1}(0.366)}$ 
17	 The reflected ray retraces its path, so it strikes the silvered face normally: $r_2 = 0$. $A = r_1 + r_2 \Rightarrow r_1 = A$ Snell's law at the first face: $1 \times \sin 2A = n \sin A$ $2 \sin A \cos A = n \sin A$ $\mathbf{n = 2 \cos A}$
18	 Magnifying power (final image at infinity): $\mathbf{m = f_o / f_e}$
19	 $\sin i_c = 1/\mu = 1/\sqrt{2} \Rightarrow i_c = 45^\circ$ Radius of the illuminated circle: $r = h \tan i_c = h = 1 \text{ m}$ Area $= \pi r^2 = 3.14 \times (1)^2 = \mathbf{3.14 \text{ m}^2}$
20	$R = -16 \text{ cm}$ (concave mirror) $\Rightarrow f = -8 \text{ cm}$ $m = -v/u = -2 \Rightarrow v = 2u$ $1/v + 1/u = 1/f \Rightarrow 1/(2u) + 1/u = 1/(-8)$

	$\frac{3}{(2u)} = -\frac{1}{8} \Rightarrow \frac{2u}{3} = -8 \Rightarrow u = -12 \text{ cm}$ The object is 12 cm in front of the mirror ($u = -12 \text{ cm}$).
21	In air: $\frac{1}{f} = (n_g - 1)(\frac{1}{R_1} - \frac{1}{R_2})$, with $n_g = 1.5$ In liquid: $\frac{1}{f'} = (n_g/n_l - 1)(\frac{1}{R_1} - \frac{1}{R_2})$, with $n_l = 1.25$ $f'/f = (n_g - 1)/(n_g/n_l - 1) = (1.5 - 1)/(1.5/1.25 - 1) = 0.5/0.2 = 2.5$ $f' = 2.5 \times 20 = \mathbf{50 \text{ cm}}$ Nature of the lens: converging
22	$n = c/v \dots(i)$ $n = \text{real depth} / \text{apparent depth} = 12.5/9 \dots(ii)$ From (i) and (ii): $v = (3 \times 10^8 \times 9)/12.5 = \mathbf{2.16 \times 10^8 \text{ m/s}}$
23	 For the image formed by lens A: $\frac{1}{v_1} - \frac{1}{u} = \frac{1}{f_1} \dots(i)$ For the image formed by lens B (I_1 acts as the object): $\frac{1}{v} - \frac{1}{v_1} = \frac{1}{f_2} \dots(ii)$ Adding (i) and (ii): $\frac{1}{v} - \frac{1}{u} = \frac{1}{f_1} + \frac{1}{f_2}$ For the combination, $\frac{1}{v} - \frac{1}{u} = \frac{1}{f} \Rightarrow \frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$ $\mathbf{f = f_1 f_2 / (f_1 + f_2)}$
24	$(n_2 - n_1)/R = n_2/v - n_1/u$ $(1.5 - 1.0)/24 = 1.5/v - 1.0/(-6)$ After solving, $\mathbf{v = -72/7 \approx -10.28 \text{ cm}}$ Nature of the image: virtual
25	 (i) $n = \sqrt{2}$: $\sin i_c = 1/\sqrt{2} \Rightarrow i_c = 45^\circ$. The ray enters face AB normally and is incident on AC at $45^\circ = i_c$, so the emergent ray grazes along AC. Fig-1



(ii) $n = \sqrt{3}$: $\sin i_c = 1/\sqrt{3} \Rightarrow i_c < 45^\circ$. Since $i > i_c$, the ray suffers total internal reflection (TIR) at AC.

- 26 The frequency of light depends on the source and does not change when light passes through different media, i.e. frequency is the characteristic property of the source.
The wavelength depends on the speed of light in the medium ($v = v\lambda$).

- 27 (a) When a ray of light travelling along the principal axis is incident on a spherical mirror, the incident light is normal to the surface of the mirror (angle of incidence = 0). By the laws of reflection the angle of reflection is also zero, so the ray reflects back along the same path.

OR

(b) Sign conventions for a convex lens:

1. All distances are measured from the optical centre of the lens.
2. Distances measured along the direction of the incident ray are taken as positive.
3. Distances measured opposite to the direction of the incident ray are taken as negative.
4. Height above the principal axis is taken as positive and height below the principal axis is taken as negative.

- 28 $-n_1/u + n_2/v = (n_2 - n_1)/R$
 $-1/(-50) + 1.5/v = (1.5 - 1)/20$
 $1.5/v = 1/40 - 1/50$
 $v = 300 \text{ cm (3 m)}$

Nature of the image: **real and inverted**

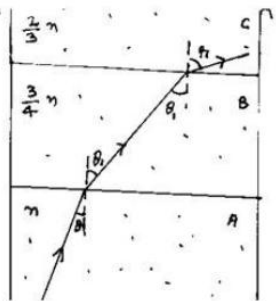
- 29 (a)

Angular magnification in normal adjustment: $|m| = f_o / f_e$

(b) Reasons for preferring a reflecting telescope (any two):

- (i) No chromatic aberration.
- (ii) Less mechanical support is required to install it.
- (iii) Image formed is brighter and clear.
- (iv) Cost efficient.
- (v) No / less spherical aberration.

- 30 (a) (i) Light must travel from a denser medium to a rarer medium.
 (ii) The angle of incidence must be greater than the critical angle ($i > i_c$).
 (b)



Refraction at the A–B interface: $\sin \theta / \sin \theta_1 = (3n/4)/n \Rightarrow \sin \theta = (3/4) \sin \theta_1 \dots(1)$

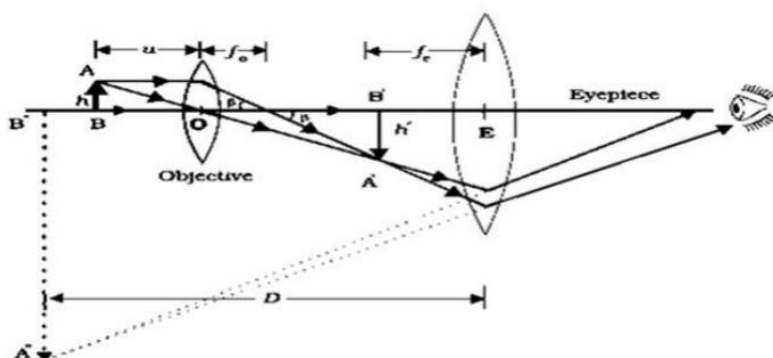
Refraction at the B–C interface: $\sin \theta_1 / \sin r = (2n/3)/(3n/4) \Rightarrow \sin \theta_1 = (8/9) \sin r \dots(2)$

From (1) and (2): $(3/2) \sin \theta = \sin r$

For $\sin \theta = 2/3$: $\sin r = 1$, i.e. $r = 90^\circ$, so the ray grazes the surface.

Hence, for $\sin \theta \geq 2/3$ the beam does not enter region C at all.

31



Magnification due to the objective lens: $m_o = h'/h = L/f_o$ (using $\tan \beta = h/f_o = h'/L$, where L is the length of the tube).

When the final image is formed at the least distance of distinct vision, the magnification produced by the eye lens is $m_e = (1 + D/f_e)$.

Total magnification: $m = m_o \times m_e \Rightarrow \mathbf{m = (L/f_o)(1 + D/f_e)}$

32

(a) In normal adjustment (image at infinity) the eye muscles remain relaxed, while they are strained when the image is formed at the near point. Hence the image at infinity is preferred.

(b) Telescope: lens L_2 is suitable as the objective and lens L_3 as the eyepiece.

Compound microscope: lens L_3 is suitable as the objective and lens L_1 as the eyepiece.

Reason: for a telescope, the objective lens should have a large aperture and large focal length. For a microscope, the objective and eye lens should have moderate aperture, but the objective should have large power.

33

For the glass–air surface: $\sin i_c = 1/n = 2/3$

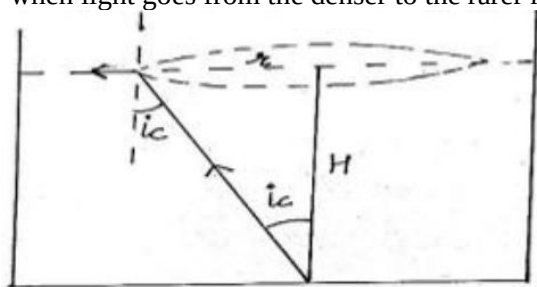
Glass–water surface: $(3/2) \sin i_c = (4/3) \sin r \Rightarrow (3/2)(2/3) = (4/3) \sin r \Rightarrow \sin r = 3/4$

Water–air surface: $(4/3) \sin r = \sin e \Rightarrow (4/3)(3/4) = \sin e \Rightarrow \sin e = 1$

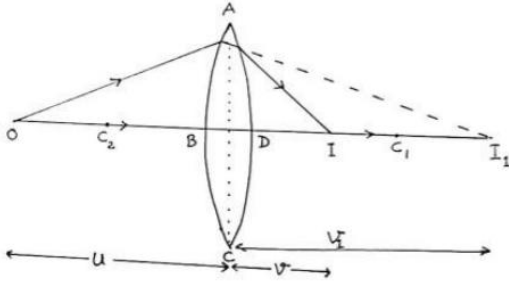
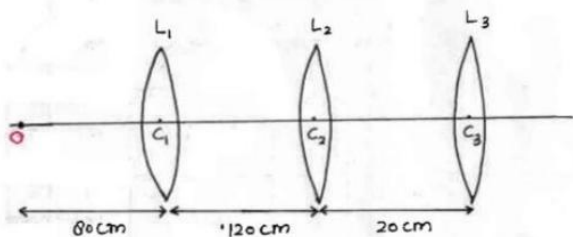
$e = 90^\circ$

34

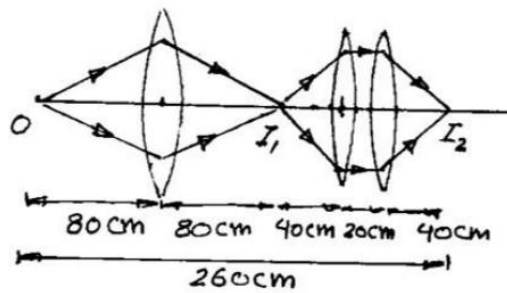
Critical angle: the angle of incidence corresponding to the angle of refraction 90° for a given pair of media, when light goes from the denser to the rarer medium.



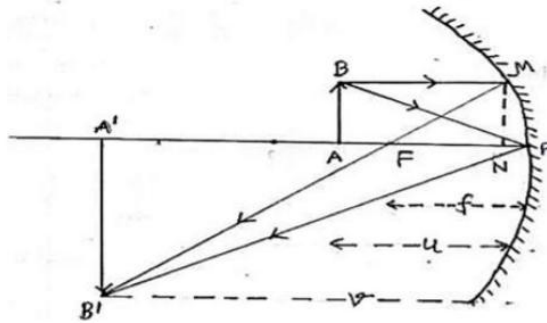
$$\sin i_c = 1/\mu = r/\sqrt{(r^2 + H^2)}$$

	$\mu^2 r^2 = r^2 + H^2 \Rightarrow (\mu^2 - 1)r^2 = H^2$ $r = H/\sqrt{(\mu^2 - 1)}$
35	(a) The ray passes symmetrically through the prism, so $r_1 = r_2 = r$ and $i = e$. $\delta_m = 2i - A = 2 \times 45^\circ - 60^\circ = 30^\circ$ (b) $r = A/2 = 30^\circ$ $\mu = \sin[(A + \delta_m)/2] / \sin(A/2) = \sin 45^\circ / \sin 30^\circ = \sqrt{2}$
36	(i) (A) $\sqrt{[D(D - 4f)]}$ (ii) (D) enlarged, reduced (iii) (B) 18.75 cm (iv) (D) 65 cm OR (iv) (A) -15 cm
37	(i) (B) real, virtual (ii) (D) apertures of objective lens and eyepiece (iii) (C) The distance between two lenses is more than $(f_o + f_e)$ (iv) (a) (A) 84 cm OR (iv) (b) (D) 20
38	(a)  The first refracting surface forms the image of the object O at I_1. For refraction from the first interface ABC: $n_1/OB + n_2/BI_1 = (n_2 - n_1)/BC_1 \dots (1)$ The image I_1 acts as a virtual object for the second surface ADC: $-n_2/DI_1 + n_1/DI = (n_2 - n_1)/DC_2 \dots (2)$ For a thin lens $BI_1 = DI_1$. Adding (1) and (2): $n_1/OB + n_1/DI = (n_2 - n_1)[1/BC_1 + 1/DC_2]$ With the sign convention: $-n_1/u + n_1/v = (n_2 - n_1)[1/R_1 - 1/R_2]$ $1/v - 1/u = (n_2/n_1 - 1)(1/R_1 - 1/R_2)$ If the object is kept at ∞, the image forms at the focus ($v = f$). Hence: $1/f = (n_2/n_1 - 1)(1/R_1 - 1/R_2)$ (b)  For lens L_1: $1/f = 1/v - 1/u \Rightarrow 1/40 = 1/v_1 + 1/80 \Rightarrow 1/v_1 = 1/80 \Rightarrow v_1 = 80 \text{ cm}$ For lens L_2: $u_2 = -(120 - 80) = -40 \text{ cm}$; $1/40 = 1/v_2 + 1/40 \Rightarrow 1/v_2 = 0 \Rightarrow v_2 = \infty$ For lens L_3: $u_3 = \infty$; $1/40 = 1/v_3 + 1/\infty \Rightarrow v_3 = 40 \text{ cm}$ Distance between the final image and the object = $80 + 120 + 20 + 40 = 260 \text{ cm}$

Alternatively:



39 (a)



ΔBAP and $\Delta B'A'P$ are similar, so $BA/B'A' = AP/A'P \dots(1)$

ΔMNF and $\Delta B'A'F$ are similar, so $MN/B'A' = NF/A'F$. Since N is very close to P and $BA = MN$: $BA/B'A' = PF/A'F \dots(2)$

From (1) and (2): $AP/A'P = PF/A'F$

$$-u/-v = -f/(-v + f)$$

$$-uv + uf = -vf$$

$$\text{Dividing by } uvf: -1/f + 1/v = -1/u$$

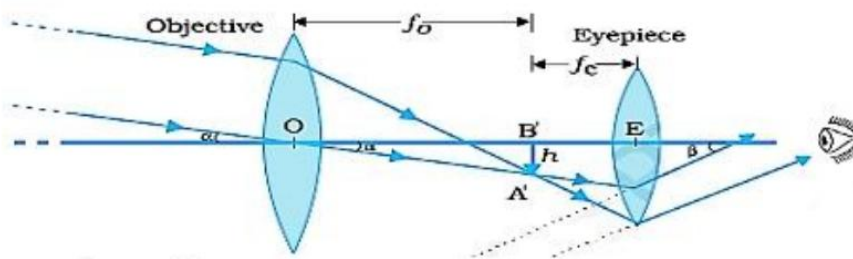
$$\mathbf{1/f = 1/v + 1/u}$$

$$(b) m = -v/u; m = 2 \Rightarrow v = -2u = -2(-10) = 20 \text{ cm}$$

$$1/f = 1/v + 1/u = 1/20 - 1/10 = (1 - 2)/20$$

$$\mathbf{f = -20 \text{ cm}}$$

40 (a)



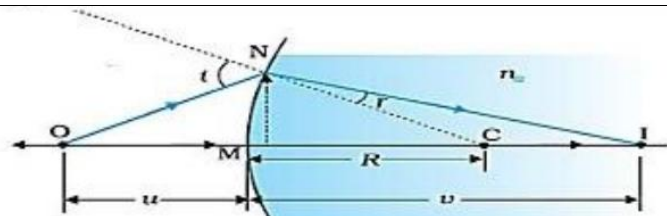
Magnifying power: $m = \beta/\alpha \approx \tan \beta / \tan \alpha = (h/f_e)/(h/f_o) \Rightarrow \mathbf{m = f_o / f_e}$

(b) (i) With a larger aperture even the fainter objects can be observed clearly. (With a larger aperture the light-gathering power and the resolving power increase.)

(ii) Advantages of a reflecting telescope (any two):

- There is no chromatic aberration in a mirror.
- Spherical aberration is removed in the case of parabolic reflectors.
- Requires less mechanical support.
- Cost effective.
- Brighter / sharper image is formed.

41 (a) (i)



For small angles: $\tan \angle NOM = MN/MO$, $\tan \angle NCM = MN/MC$, $\tan \angle NIM = MN/MI$

$$i = \angle NOM + \angle NCM = MN/MO + MN/MC \dots(1)$$

$$r = \angle NCM - \angle NIM = MN/MC - MN/MI \dots(2)$$

By Snell's law for small angles: $1 \times i = n \times r$. Substituting i and r from (1) and (2):

$$1/MO + n/MI = (n - 1)/MC \dots(3)$$

Using the Cartesian sign convention, $MO = -u$, $MI = +v$, $MC = +R$:

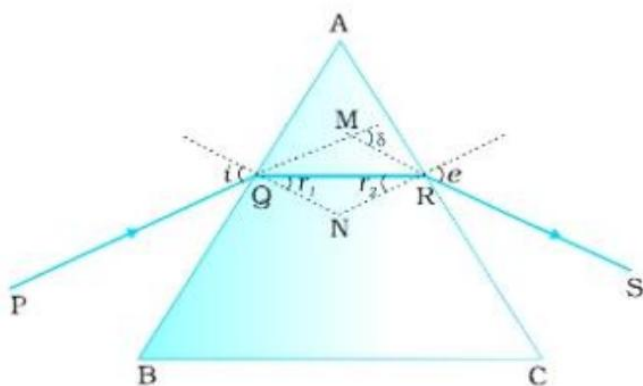
$$n/v - 1/u = (n - 1)/R$$

$$(ii) \ 1/f = 1/v - 1/u \Rightarrow 1/20 = 1/v - 1/(-30) \Rightarrow v = 60 \text{ cm}$$

Nature of the image: **real and inverted**

- 42 (i) The refractive index of a medium is the ratio of the speed of light in vacuum to the speed of light in the medium: $n = c/v$.

(ii)



In the quadrilateral AQNR, two of the angles (at the vertices Q and R) are right angles. Therefore $\angle A + \angle QNR = 180^\circ$.

From the triangle QNR: $r_1 + r_2 + \angle QNR = 180^\circ$.

Comparing these two equations: $r_1 + r_2 = A \dots(i)$

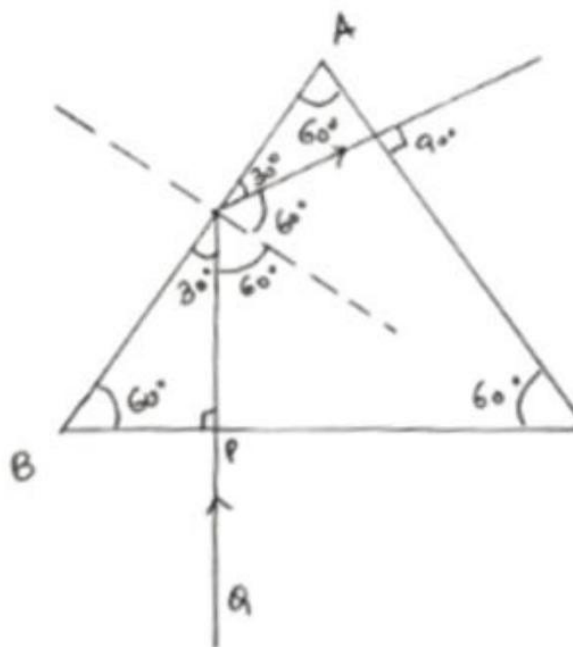
The total deviation δ is the sum of the deviations at the two faces: $\delta = i + e - A \dots(ii)$

For $\delta = \delta_m$: $i = e$, which implies $r_1 = r_2$.

From (i) and (ii): $r = A/2$; $i = (A + \delta_m)/2$

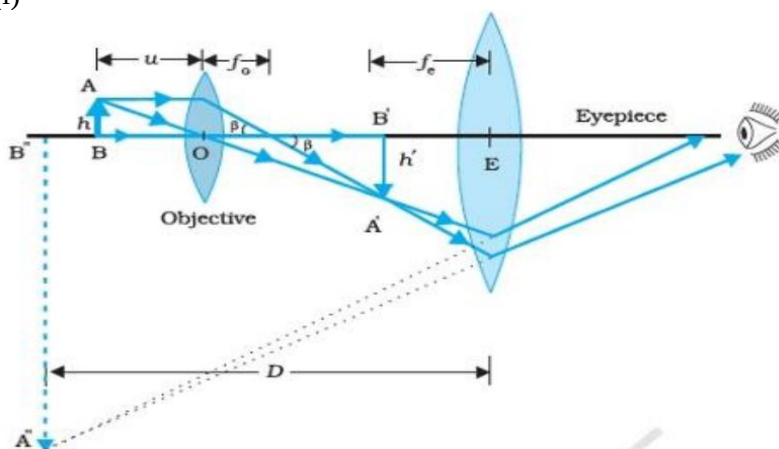
Refractive index of the prism: $n_{21} = n_2/n_1 = \sin[(A + \delta_m)/2] / \sin(A/2)$

(iii)



The ray QP strikes the face BC normally and hence goes undeviated. As $i > i_c$, it undergoes total internal reflection. It strikes the face AC normally and comes out undeviated.

43 (i)



Construction: It consists of two convex lenses – the objective lens with a small aperture placed near the object, and the eyepiece with a large aperture placed near the eye. Both lenses have small focal lengths. These lenses are placed coaxially in a narrow tube with a rack and pinion arrangement.

Working: The lens near the object, called the objective, forms a real, inverted and magnified image of the object. This serves as the object for the eyepiece, which produces the final image, enlarged and virtual.

(ii) (I) **Yes.** A real image is formed by the actual intersection of rays.

(II) **Yes.** If the object is virtual.

- 44 (a) Working of a reflecting-type telescope: Parallel rays from a distant object (star) enter the telescope parallel to the principal axis of the mirror and tend to collect at the focus of the concave mirror. These reflected rays encounter a secondary convex mirror before meeting at the focus; the convex mirror reflects them to the eyepiece. The final image is seen through the eyepiece and is inverted with respect to the object. Advantages over a refracting telescope (any two): (1) free from chromatic aberration; (2) free from spherical aberration; (3) requires less mechanical support; (4) low cost.
- (b) (i) Final image at infinity: $m = -f_o/f_e = -125/5 = -25$
- (ii) Final image at 25 cm: $m = -(f_o/f_e)(1 + f_e/D) = -(125/5)(1 + 5/25) = -30$

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