

CHAPTER 09

REFLECTION OF LIGHT



Mirror Formula

$$\frac{f}{f} = \frac{1}{v} + \frac{1}{u}$$

Focal Length

$$f = \frac{R}{2}$$

Linear Magnification

$$m = \frac{h'}{h} = -\frac{v}{u}$$



REFRACTION OF LIGHT



Snell's Law

$$\frac{\sin i}{\sin r} = n_{21} = \frac{n_2}{n_1}$$

Apparent Depth

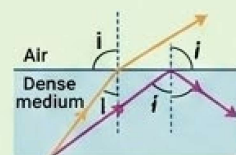
$$\text{Apparent Depth} = \frac{\text{Real Depth}}{n}$$

Refractive Index

$$n = \frac{c}{v}$$

Critical Angle

$$\sin C = \frac{1}{n} \quad \text{TIR Condition: } i > C$$



SPHERICAL SURFACES & LENSES



Refraction at Spherical Surface

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{(n_2 - n_1)}{R}$$

Thin Lens Formula

$$\frac{1}{f} = \frac{1}{v} - \frac{1}{u}$$

Lens Maker's Formula

$$\frac{1}{f} = \left(\frac{n_2}{n_1} - 1 \right) \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$$

Magnification

$$m = \frac{v}{u}$$



PRISMS



Angle of Deviation

$$\delta = i + e - A$$

Deviation for Small-Angle Prism

$$\delta = (n - 1)A$$

Prism Formula

$$n = \frac{\sin((A + D_m)/2)}{\sin(A/2)}$$

LENS COMBINATIONS & POWER



Power

$$P = \frac{1}{f} \text{ (in meters)}$$

Combination Power

$$P_{eq} = P_1 + P_2 + \dots$$

Equivalent Focal Length

$$\frac{1}{F_{eq}} = \frac{1}{f_1} + \frac{1}{f_2} + \dots$$

OPTICAL INSTRUMENTS



Simple Microscope

$$M = 1 + \frac{D}{f} \text{ (near point)}$$

$$M = \frac{D}{f} \text{ (infinity)}$$

Compound Microscope

$$M \approx \left(\frac{L}{f_o} \right) \left(\frac{D}{f_e} \right)$$

Astronomical Telescope

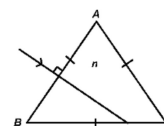
$$M = \frac{f_o}{f_e} \text{ (Normal Adjustment)}$$

$$\text{Length } L = f_o + f_e$$



MULTIPLE CHOICE QUESTIONS

1. A beam of light is incident at 60° to a plane surface. The reflected and refracted rays are perpendicular to each other. What is the refractive index of the surface?
 (a) $1/\sqrt{3}$ (b) $\sqrt{3}$ (c) $1/3$ (d) 3
2. A concave mirror of focal length f produces a real and virtual image of an object of magnification m ($m > 1$) when placed at two different positions. The distance between the positions of the object is :
 (a) $(m - 1)f$ (b) $(1 - m)f$ (c) $\frac{2f}{m}$ (d) zero
3. Two convex lenses are of focal length 20cm and 30cm are kept parallel to each other such that a parallel beam of incident light emerges out of the system parallel to the principal axis. The separation between the lenses must be
 (a) 10cm (b) 20cm (c) 30cm (d) 50cm
4. A concave lens of focal length 20cm is cut into two equal parts perpendicular to the principal axis the power of each part will be
 (a) -2.5D (b) -5D (c) -10D (d) -20D
5. Which of the following is not true about refraction of light through a glass slab
 (a) The angle of incidence and emergence are equal
 (b) Some part of incident light is reflected
 (c) Light slows down inside the glass slab
 (d) The lateral deviation is independent of angle of incidence.
6. The least value of refractive index 'n' for material of prism so that the light grazes along BC will be
 (a) $1/\sqrt{3}$ (b) $2/\sqrt{3}$ (c) $\sqrt{3/2}$ (d) $\sqrt{3}$
7. The refractive index of the material of a prism is $\sqrt{2}$ and its refracting angle is 30° . One of the refracting surfaces of the prism is made a mirror. A beam of monochromatic light entering the prism from the other face retraces its path, after reflection from mirror surface. The angle of incidence on prism is:
 (a) 0° (b) 30° (c) 45° (d) 60°
8. An astronomical refractive telescope has an objective of focal length 20 m and an eyepiece of focal length 2 cm. Then in normal adjustment:
 (a) the angular magnification is 1000
 (b) the length of the telescope tube is 20.02 m
 (c) the image formed is of inverted nature. (d) all of these
9. A particle moves towards a concave mirror of focal length 30 cm along its axis and with a constant speed of 4 cm/ sec. What is the speed of its image when the particle is at 90 cm from the mirror?
 (a) 16 cm/ sec. (b) 1 cm/sec. (c) 8 cm/sec. (d) 4 cm/sec.
10. Two identical thin convex lens each of power P are in contact. A third lens is kept in contact with them so that the power of whole system is P only. The third lens must be a
 (a) Convex lens of power $P/3$ (b) Concave lens of power $P/2$
 (c) Convex lens of power $P/2$ (d) Concave lens of power P



11 A square of side 1cm is viewed through a convex lens of focal length 'f' such that their distance is half the focal length. The area of the square in the image will be

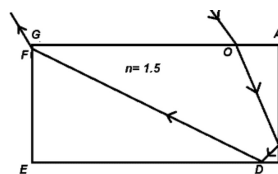
- (a) 4 cm^2 (b) 2.25 cm^2 (c) 1.44 cm^2 (d) 1 cm^2

12 A lens made of material of Refractive index 'n' changes its nature in a medium of refractive index ' n_1 ' but disappears in a medium of refractive index ' n_2 '. The ratio $n_1 : n_2$ is 'x'. Choose the correct option

- (a) $x > 1$ (b) $x = 1$ (c) $0 < x < 1$ (d) $x < 0$

13 A beam of light moves into a glass slab of refractive index 1.5 as shown in figure. If $OA = 3 \text{ cm}$, $AB = 4 \text{ cm}$, $BC = CD = 1 \text{ cm}$, $DE = 12 \text{ cm}$ and FG is negligible, the time spent by light ray in the glass slab will be

- (a) 0.65 ns (b) 0.78 ns (c) 0.97 ns (d) 1.06 ns



14 If an object is kept at the focus of a concave lens of focal length 50cm the image will be

- (a) Virtual at infinity (b) real at infinity
(b) Virtual at 25cm (d) real at 25cm

15 When light suffers total internal reflection its phase changes by

- (a) Zero (b) 90° (c) 180° (d) x and x varies with wavelength

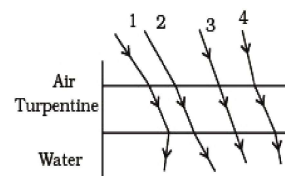
16 If we dip a prism in water the minimum angle of deviation due to it will

- (a) Decrease (b) not change (c) increase (d) depend on i (angle of incidence)

17 You are given four sources of light each one providing a light of a single colour – red, blue, green and yellow. Suppose the angle of refraction for a beam of yellow light corresponding to a particular angle of incidence at the interface of two media is 90° . Which of the following statements is correct if the source of yellow light is replaced with that of other lights without changing the angle of incidence?

- (a) The beam of red light would undergo total internal reflection.
(b) The beam of red light would bend towards normal while it gets refracted through the second medium.
(c) The beam of blue light would undergo total internal reflection.
(d) The beam of green light would bend away from the normal as it gets refracted through the second medium

18 The optical density of turpentine is higher than that of water while its mass density is lower. Fig shows a layer of turpentine floating over water in a container. For which one of the four rays incident on turpentine in Fig the path shown is correct?



- (a) 1 (b) 2 (c) 3 (d) 4

19 If I is the image of a point object O formed by spherical mirror, then which of the following statement is incorrect:

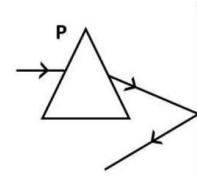
- a) If O and I are on same side of the principal axis, then they have to be on opposite sides of the mirror.
b) If O and I are on opposite sides of the principal axis, then they have to be on same side of the mirror.
c) If O and I are on opposite side of the principal axis, then they can be on opposite side of

the mirror as well at same side of the mirror.

d) If O is on principal axis then I may not lie on principal axis.

- 20 A prism having an apex angle of 4° and refractive index of 1.50 is located in front of a vertical plane mirror as shown. A horizontal ray of light is incident on the prism. The total angle through which the ray is deviated is

a) 4° clockwise b) 178° clockwise
c) 2° clockwise d) 8° clockwise



- 21 A plano concave lens of focal length 10 cm is placed on a paper on which a coin is drawn. How far above its actual position does the coin appear to be?

a) 10 cm b) 15 cm c) 50 cm d) none of these

Answers

1. (b), 2. (c), 3. (d), 4. (a), 5. (d), 6. (b), 7. (c), 8. (d), 9. (b), 10. (d), 11. (a), 12. (a), 13. (c), 14. (c), 15. (d), 16. (a), 17. (c), 18. (b), 19. (d), 20. (b), 21. (d)

EXERCISE QUESTIONS

- 10 A source of red color is placed in front of a convex lens its diminished real image of almost same size is formed now red color source is replaced by blue color source choose the correct option:

a) Its real image is not formed. b) Slightly enlarged real images is formed
c) Highly diminished real image is formed. d) Nothing can be said.

- 11 A concave mirror of focal length ' f_1 ' is placed at a distance of ' d ' from a convex lens of focal Length ' f_2 '. A beam of light coming from infinity and falling on this convex lens-concave mirror combination returns to infinity. The distance ' d ' must equal :

a) $f_1 + f_2$ b) f_1 c) f_2 d) a or b

- 12 A convex mirror forms virtual image of a point object at d distance from Its pole. It is cut horizontally into two equal parts and one part is removed. New position of image is found
a) same at d b) slightly away from d c) Slightly closer d) No images is formed to pole

- 13 A lens is made of flint glass (refractive index = 1.5). When the lens is immersed in a liquid of refractive index 1.25, the focal length

a) Increases by a factor of 1.5 c) Increases by a factor of 1.2
b) Decreases to a factor of 2.5 d) Decreases to a factor of

- 14 A bulb is located on a wall. Its image is to be obtained on a parallel wall with the help of convex lens. If the distance between parallel walls is ' d ' then required focal length of lens placed in between the walls is

a) Only $d/4$ b) Only $d/2$
c) More than $d/4$ but less than $d/2$ d) Less than or equal to $d/4$

Answers : 11 c) 12 c) 13 d) 14 a) 15 d)

ASSERTION-REASON TYPE QUESTIONS

For these Questions two statements are given one labelled Assertion (A) and other labelled Reason (R). Select the correct answer to these questions from the options as given below

A. If both Assertion and Reason are true and Reason is correct explanation of Assertion.
B. If both Assertion and Reason are true but Reason is not the correct explanation of Assertion.

C. If Assertion is true but Reason is false.

D. If both Assertion and Reason are false.

1. **Assertion:** The images formed by total internal reflections are much brighter than those

formed by mirrors or lenses.

Reason: There is no loss of intensity in total internal reflection.

- 2 **Assertion:** When light enters inside perfectly spherical water droplet it should not show total internal reflection inside the water droplet.

Reason: When light enters non perpendicular to spherical water droplet it is internally reflected.

- 3 **Assertion:** Law of reflection is applicable for all type of mirrors.

Reason: Rays which are parallel to principal axis are known as paraxial rays

4. **Assertion:** If objective and eye lenses of a microscope are interchanged then it can work as telescope.

Reason: The objective of telescope has small focal length.

5. **Assertion:** When water is filled inside a transparent drinking glass it may act like a lens.

Reason: Whenever the surface on which light is incident and the surface from which light is emerging out are parallel, we get dispersion of light.

- 6 **Assertion:** The formation of rainbow involves total internal reflection.

Reason: light source shall be in front of the observer to see a rainbow

- 7 **Assertion:** A prism bends incident light towards its apex angle

Reason: angle of minimum deviation due to prism is more for greater angle of incidence

- 8 **Assertion:** A glass slab does not show any dispersion

Reason: The speed of light in a depends on wavelength of light

- 9 **Assertion:** Refraction at a spherical surface can lead to an image that can be real or virtual.

Reason : A real image is formed when rays actually meet at a point physically.

- 10 **Assertion:** An object must be placed just outside the focus of objective in a compound microscope.

Reason: The objective shall form a real image that would be the object for eyepiece

Answers

1. a 2. d 3. b 4.d 5.c 6.c 7.d 8.b 9.b 10. a

EXERCISE QUESTION

1. **Assertion:** A concave mirror has $f = 40$ cm in air. It has $f = 10$ cm in water.

Reason: Focal length of a mirror is dependent of medium.

2. **Assertion:** A double convex lens ($n = 1.5$) has focal length 10 cm. When the lens is immersed in water ($n = 4/3$) its focal length becomes 40 cm.

Reason: Because the focal length of lens in liquid $\frac{1}{f} = \frac{n_l - n_m}{n_m} \left(\frac{1}{R_1} - \frac{1}{R_2} \right)$

1. **Assertion:** Power of a lens depends on nature of material of lens, medium in which it is placed and magnitude radii of curvature of its surface.

Reason: Image formed by a convex mirror is always smaller in size.

4. **Assertion:** A ray of light travelling in air is incident on a glass slab. The ray gets partly reflected and partly refracted. The phase difference between the reflected and the refracted waves is non zero

Reason: Images formed by plane mirrors can not be photographed.

5. **Assertion:** The frequencies of incident, reflected and refracted beam of monochromatic light incident from one medium to another are same

Reason: The incident, reflected and refracted rays are coplanar.

ANSWERS

1. D 2. A 3.B 4.C 5.B

SHORT ANSWER TYPE QUESTIONS

- 1 When we move away from a tower its height appears to decrease. Give reason?
2. Does the apparent depth of a tank of water change if viewed obliquely at different angles? If so, does the apparent depth increase or decrease?
3. Draw the ray for refraction of light through an air bubble inside water. Show that it is a divergent system.
4. Focal length is 50% of radius of curvature. Is it true about a lens?
5. For a thin glass prism the angle of minimum deviation is 20% of the prism angle. Find the refractive index for the material of the prism.
6. When the object is at distances u_1 & u_2 the images formed by the same lens are real and virtual respectively and of the same size. Calculate focal length of the lens?
7. What is the principle for endoscopic examination of patients in hospital?
8. Will the focal length of a lens for red light be more, same or less than that for blue light? Justify?
9. The focal length of an equiconvex lens is equal to the radius of curvature of either face. What is the value of refractive index of the material of the lens?
10. Write advantages of reflecting type telescope over refracting type telescope.

Answers

1. This occurs because the visual angle subtended by the tower at the eye decreases as distance increases, making it appear smaller.
2. Yes; it decreases as the viewing angle becomes more oblique due to greater refraction at the water-air interface.
3. An air bubble acts as a diverging lens because light travels from a denser medium (water) to a rarer medium (air), bending away from the normal upon entry and exit.
4. No; the relation $f = R/2$ applies only to spherical mirrors. For lenses, focal length depends on the refractive index and surface radii via the Lens Maker's Formula.
5. The refractive index is $n = 1.20$, calculated using the thin prism formula $\delta = (n - 1) A$ with $\delta = 0.20A$.
6. The focal length is $f = -(u_1 + u_2) / 2$, derived by equating the magnifications for real and virtual images of the same size.
7. The operating principle is Total Internal Reflection (TIR), utilizing optical fibers to transit light through curved paths inside the body.
8. Focal length for red light is more because it has a longer wavelength and lower refractive index than blue light, and f is inversely proportional to $(n - 1)$.
9. The refractive index is $n = 1.5$, determined by the Lens Maker's Formula for an equiconvex lens where $f = R$.

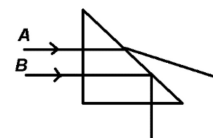
10. Key advantages include the absence of chromatic aberration, easier structural support for large mirrors, correction of spherical aberration with parabolic shapes, and lower manufacturing costs.

Practice questions

Q1 How come sunglasses are claimed as powerless though they are made of curved spherical surfaces of transparent nature (finite refractive index)?

Q2 if ${}_1^2n = 1.4$, ${}_2^3n = 1.5$ and ${}_3^4n = 1.6$ find refractive index of 4th medium w.r.t. 1st medium. Out of these four media in which the light will travel fastest?

(Note : here ${}_1^2n$ means refractive index of 2nd medium w.r.t. 1st medium)



Q3 Two light beams A and B are incident on a triangular prism as shown. Based on the ray diagram shown explain which of the two (A or B) has a greater wavelength.

4. Show that for a material with refractive index $\mu \geq \sqrt{2}$, light incident at any angle shall be guided along a length perpendicular to the incident face.

5. A ray of light is incident on a parallel slab of thickness t and refractive index n . If the angle of incidence θ is small, Express the displacement in the incident and emergent ray?

Answers

Ans 1 . Sunglasses are considered 'powerless' because both the front and back surfaces of the lens have the same radius of curvature ($R_1 = R_2$). According to the Lens Maker's Formula: $P = (n - 1) (1/R_1 - 1/R_2)$. Since the surfaces are parallel and curved in the same direction, $R_1 = R_2$. This makes the term $(1/R_1 - 1/R_2)$ equal to zero, resulting in a net optical power (P) of zero.

Ans2: Given: ${}_1^2n = 1.4$, ${}_2^3n = 1.5$, ${}_3^4n = 1.6$, To find the refractive index of the 4th medium w.r.t. the 1st medium We know that ${}_1^4n = {}_1^2n \times {}_2^3n \times {}_3^4n$ Since ${}_3^4n = 1 / {}_4^3n = 1 / 1.6$
 ${}_1^4n = 1.4 \times 1.5 \times (1 / 1.6) = 2.1 / 1.6 = 1.3125$. Light travels fastest in the medium with the lowest absolute refractive index. So medium 4

Ans3: In the ray diagram, Beam A undergoes refraction at the hypotenuse, while Beam B undergoes Total Internal Reflection (TIR). TIR occurs when the angle of incidence is greater than the critical angle (θ_c). Since both beams have the same angle of incidence, Beam B must have a smaller critical angle than Beam A. Since $\sin \theta_c = 1/n$, a smaller critical angle implies a higher refractive index (n). Thus, $n_B > n_A$. According to Cauchy's formula, refractive index is inversely proportional to wavelength ($n \propto 1/\lambda^2$). Since $n_B > n_A$, then $\lambda_A > \lambda_B$. Therefore, Beam A has the greater wavelength.

Ans 4: Consider a ray incident at the maximum possible angle (90°) on the end face of a rod.

By Snell's Law at entrance: $1 \cdot \sin(90^\circ) = \mu \cdot \sin(r) \Rightarrow \sin(r) = 1/\mu$

For the light to be guided (undergo TIR at the side wall), the angle of incidence at the wall ($90^\circ - r$) must be $\geq$ Critical angle (θ_c). $\sin(90^\circ - r) \geq \sin(\theta_c) \Rightarrow \cos(r) \geq 1/\mu \Rightarrow$ Squaring both sides: $\cos^2(r) \geq 1/\mu^2$, so $1 - \sin^2(r) \geq 1/\mu^2 \Rightarrow \mu \geq \sqrt{2}$

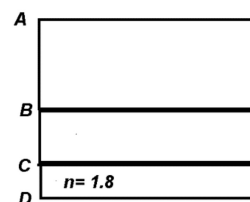
Ans 5: The lateral displacement (d) of a ray passing through a slab is given by: $d = t \cdot \sin(\theta - r) / \cos(r)$. For small angles, $\sin(\theta - r) \approx \theta - r$ and $\cos(r) \approx 1$.

$d \approx t(\theta - r)$. From Snell's law for small angles: $\theta = n \cdot r \Rightarrow r = \theta/n$. Substituting r : $d \approx t(\theta - \theta/n) = t \cdot \theta (1 - 1/n)$

Short answer Type II

Q1 Draw the u-v graph (cgs units) for a convex lens. if on this graph there is point having coordinates(50,50). What's the significance of this information? How can we locate that point on a given u-v graph?

Q2 Three slabs of height in the ratio 1:2:3 (lowest being 2cm) and Refractive indices in the ratio 6:5:4 (highest being 1.8) are placed One over the other respectively. Find the apparent shift in the Position of a spot on a paper kept below the slab at the bottom. (See figure, CD= 2cm)



Q3 Light From infinity falls on a globe of radius 40cm having refractive index 1.5. Find the point at which light will be focused.

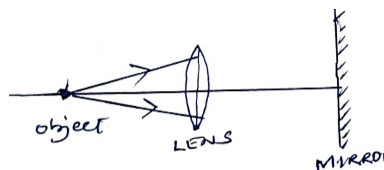
Q 4 A convex lens of focal length 5cm is used as a simple microscope. Find the minimum and maximum magnifying power that can be obtained from it. Discuss the case when the object is kept 3.5cm away from the lens.

Q5 A convergent light beam is focused at point P from left. A concave lens is placed at a fixed point 'Q' between light beam and 'P'. If a convex lens is kept in the path of emergent beam the distance between the final image and convex lens doesn't change irrespective of position of convex lens. Draw the ray diagram to explain the situation. What will be the focal length of concave lens?

Q6 How come sunglasses are claimed as powerless though they are made of curved spherical surfaces of transparent nature (finite refractive index)?

Q7 if ${}_1^2n = 1.4$, ${}_2^3n = 1.5$ and ${}_4^3n = 1.6$ find refractive index of 4th medium w.r.t. 1st medium. Out of these four media in which the light will travel fastest? (Note : here ${}_2^1n$ means refractive index of 2nd medium w.r.t. 1st medium)

Q8 A convex lens of focal length f is placed x metre apart from a plane mirror. As shown in figure an object is placed at x distance from the lens away from the mirror get a relation between x and f for following conditions



- if final image is formed at x. (at the position of object itself)
- if no images formed.
- if virtual images are formed.

Q9. A convex lens and a concave lens have power in ratio 3:2 when placed in contact effective focal length of combination is found 30 cm. We get real image of an object which is placed at 15 cm in front of convex lens. This image is shifted by 20 cm when same concave lens is introduced between convex lens and image. Calculate the position of the lens introduced. Hence draw necessary ray diagram.

Q10. You have a concave mirror placed horizontally on a Floor. An all pin when placed at d_1 meter above it, its real image coincide with itself. This mirror is filled with a liquid of refractive index n_1 new image is found at D_2 if this liquid is replaced by another liquid of refractive index n_2 new image is found at D_3 . If $n_1 > n_2$ give a relation between D_2 and D_3 with proper justification using a diagram.

Answers

Ans1. The u - v graph for a convex lens is a rectangular hyperbola in the second and fourth quadrants (if using Cartesian sign convention). In cgs units, the point (50, 50) signifies that when the object distance $u = -50$ cm, the image distance $v = 50$ cm.

Significance: At this point, $|u| = |v| = 2f$. Thus, $2f = 50$ cm, which gives the focal length $f = 25$ cm. The image is real, inverted, and of the same size as the object.

Locating the point: Draw a line $v = u$ (or a line at 45° to the axes passing through the origin).

The intersection of this line with the hyperbola gives the point where $u = v = 2f$.

Ans2. Height ratio 1:2:3. Lowest (h_1) = 2 cm, so $h_2 = 4$ cm and $h_3 = 6$ cm.

Refractive index ratio 6:5:4. Highest (n_1) = 1.8, so $n_2 = (5/6) \cdot 1.8 = 1.5$ and $n_3 = (4/6) \cdot 1.8 = 1.2$. Total Apparent Shift (Δs) = $\sum h_i \cdot (1 - 1/n_i)$. $\Delta s = 2(1 - 1/1.8) + 4(1 - 1/1.5) + 6(1 - 1/1.2)$

$\Delta s = 2(0.8/1.8) + 4(0.5/1.5) + 6(0.2/1.2) = 2(4/9) + 4(1/3) + 6(1/6)$. $\Delta s = 8/9 + 4/3 + 1 = (8 + 12 + 9)/9 = 29/9 \approx 3.22$ cm.

Ans3. First refraction: $n_1=1$, $n_2=1.5$, $u=\infty$, $R=40$ cm. Using $(n_2/v) - (n_1/u) = (n_2-n_1)/R$

$(1.5/v_1) - 0 = (1.5-1)/40 \Rightarrow 1.5/v_1 = 0.5/40 \Rightarrow v_1 = 120$ cm from the first surface. Second refraction: $u_2 = v_1 - \text{Diameter} = 120 - 80 = 40$ cm (inside globe, directed towards second surface).

$n_1=1.5$, $n_2=1$, $R=-40$ cm. $(1/v_2) - (1.5/40) = (1-1.5)/(-40) \Rightarrow 1/v_2 = 0.5/40 + 1.5/40 = 2/40 = 1/20$. $v_2 = 20$ cm from the second surface (60 cm from the center).

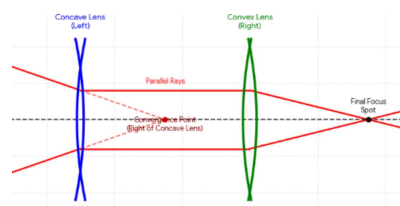
Ans 4 Minimum Magnifying Power (at infinity): $M_{\min} = D/f = 25/5 = 5$.

Maximum Magnifying Power (at D): $M_{\max} = 1 + D/f = 1 + 25/5 = 6$.

Case $u = 3.5$ cm: $m = D/u = 25/3.5 = 7.13$

This is more than maximum m but not useful as in this case $v < D = 25$ cm so blurred image will be formed

Ans 5 If the position of the final image after a convex lens doesn't change regardless of the lens's position, the emergent beam from the concave lens must be parallel (at infinity). This happens if the convergent beam (meeting at P) is incident on the concave lens such that point P acts as its virtual focus (F). Thus, Focal length of concave lens = Distance QP.



Ans 6 Sunglasses have curved surfaces where the radii of curvature of the front and back surfaces are equal ($R_1 = R_2$).

Using Lens Maker's Formula: $P = (n - 1)(1/R_1 - 1/R_2)$. Since $R_1 = R_2$, $P = 0$. Thus, they are powerless.

Ans 7 $n_{43} = n_{42} \cdot n_{23} \cdot n_{31}$. Given $n_{42} = 1.4$, $n_{23} = 1.5$, $n_{43} = 1.6$. $n_{31} = 1/n_{13} = 1/1.4$; $n_{32} = 1/n_{23} = 1/1.5$. $n_{41} = 1.6 \cdot (1/1.5) \cdot (1/1.4) = 1.6 / 2.1 \approx 0.76$.

Velocity $v = c/n$. Light travels fastest in the medium with the lowest absolute refractive index. Based on the ratios, medium 4 is the rarest w.r.t others, so light travels fastest in medium 4.

Ans 8 a) Image at x : The rays must retrace their path. This occurs if light falls normally on the mirror. The image from the lens must be at infinity, so $x = f$.

b) No image: If the virtual image by the lens coincides with the plane mirror's surface or if light never converges. Practically, if the object is at f , rays are parallel and no real image forms.

c) Virtual image: If the object is placed within the focal length, i.e., $x < f$.

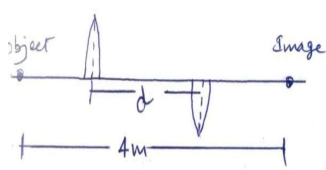
Ans 9 Power ratio 3:2, focal length ratio 2:3. Let $f_1 = 2k$, $f_2 = -3k$. $1/F = 1/f_1 + 1/f_2 \Rightarrow 1/30 = 1/2k - 1/3k = 1/6k \Rightarrow 6k = 30 \Rightarrow k = 5$. $f_{\text{convex}} = 10$ cm, $f_{\text{concave}} = -15$ cm.

Object at 15 cm from convex lens: $1/v - 1/(-15) = 1/10 \Rightarrow 1/v = 1/10 - 1/15 = 1/30 \Rightarrow v = 30$ cm. When concave lens is introduced, image shifts by 20 cm (moves to $30 + 20 = 50$ cm).

For concave lens: Object is the virtual image at 30cm. Let lens be at distance 'd' from convex lens. $u_{\text{concave}} = 30 - d$. $v_{\text{concave}} = 50 - d$. $1/(50-d) - 1/(30-d) = 1/(-15)$. Solving for d gives the position.

Ans 10 For a mirror filled with liquid, the effective focal length decreases. Since $n_1 > n_2$, the liquid with n_1 is denser. D_2 and D_3 are related to the apparent depth and the radius of curvature. $D_2 < D_3$ because the denser liquid (n_1) causes a greater shift/refraction, bringing the coincidence point closer.

Practice Problems

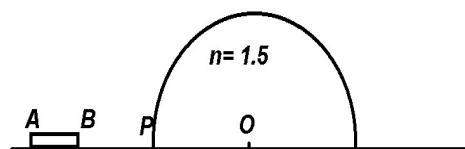
1. In case of a concave mirror magnification is found to be - 0.5 for a certain position of object, when object is displaced by 5 cm from its position, magnification becomes 0.25. What will be the focal length of the mirror? Draw ray diagram to support your answer.
2. You have two mirrors one is concave other is convex focal of each mirror is 30 cm are placed D m apart such that their principal axis are common to each other. An object is placed between them at a point P which is 45 cm from concave mirror. It is found that final images formed on object itself Draw probable ray diagram and calculate value of D?
3. When we use an astronomical telescope, we say there must be a certain minimum and maximum length of the Telescopic tube, which means distance between objective lens and eye lens should not have a value beyond a minimum value and a maximum value. Justify? Draw appropriate diagram where necessary.
4. (a) A right angle isosceles prism bends a ray of light by 90° when the ray incidents normal to its one smaller face. What may be the maximum or maximum possible values of refractive index of the medium of the prism?
(b) If this prism is taken to analyze bending of different colors it is observed that when yellow colour incidents perpendicular to its one small face emergent ray shows angle of deviation 45° . Draw a diagram showing refraction of green, red, blue and yellow colors.
5. A convex lens has focal length f in air. How its focal length would change in following cases:
 - a) surrounding medium is made slightly optical denser than it
 - b) surrounding medium is made slightly optical denser than air
 - c) surrounding medium is made slightly optical rarer than air
6. A convex lens with focal length f is cut into two equal parts horizontally as shown in figure. These two parts are shifted away along principal axis up to a separation of d m. An object and its image formed by this combination has separation of 4m. If magnification produced by one part is - 3.0. Calculate F & d, draw probable Ray diagram.
 
7. There is a concave mirror of radius of curvature 30 cm. A U-shaped wire of dimensions 15 cm, 15 cm and 15 cm is placed vertically in front of it along its axis such that its minimum distance from the pole of the mirror is 45 cm. Find total length of the image formed? Draw ray diagram to support your answer.
8. There is a plano convex lens whose radius of curvature is 2.5 cm and maximum thickness is 9 cm and object are placed at certain distance from the convex surface then its images formed at plane surface. If refractive index of the medium is 1.5, calculate magnification produced?

Q9 A student performs the experiment to find refractive index of material of an equilateral glass prism. The readings obtained by him are given below. Now he claims that the minimum deviation shown by the prism is 37° . Support (or criticize) his claim by suitable mathematical calculations.

Angle of incidence	35°	40°	45°	50°	55°	60°
Angle of deviation	41°	39°	37.5°	37°	38°	39°

Find the refractive index of the material of the prism based on his readings.

Q10 A bar AB of length 10cm is placed along the principal axis 20cm away from a transparent hemispherical glass sphere of radius 30cm (see figure) Find the length of image of the bar so formed.



Answers

Ans 1 Formula: $m = f / (f - u)$, **Final Answer:** $f = 5/6$ cm (or 0.83 cm)

Ans 2 Formula: $1/v + 1/u = 1/f$ and $D = v_1 - R_2$ **Final Answer:** $D = 30$ cm

Ans 3 Formula: $L_{\max} = f_o + f_e$; $L_{\min} = f_o + (f_e * D) / (f_e + D)$

Final Answer: Length ranges from $f_o + (f_e * D) / (f_e + D)$ to $f_o + f_e$

Ans 4 Formula: $n = 1 / \sin(c)$; deviation = $(n-1)A$

Final Answer: $n_{\min} = 1.414$; Blue deviates most, Red deviates least

Ans 5 Formula: $1/f = (n_{\text{lens}} / n_{\text{medium}} - 1)(1/R_1 - 1/R_2)$

Final Answer: f increases as n_{medium} increases (if $n_{\text{medium}} < n_{\text{lens}}$)

Ans 6 Formula: $1/v - 1/u = 1/f$; $m = v/u$ **Final Answer:** $f = 0.75$ m

Ans 7 Formula: $1/v + 1/u = 1/f$; $m = -v/u$ **Final Answer:** Total length = 15 cm

Ans 8 Formula: $n_2/v - n_1/u = (n_2 - n_1)/R$; $m = (n_1 * v) / (n_2 * u)$. Magnification = -0.2

Ans 9 Formula: $n = \sin((A + D_m)/2) / \sin(A/2)$. $n = 1.50$ (Claim for $D_m = 37^\circ$ is supported)

Ans 10 Formula: $n_2/v - n_1/u = (n_2 - n_1)/R$ **Final Answer:** Length of image = 45 cm

LONG ANSWER TYPE QUESTIONS

- a) Draw a labeled ray diagram of a simple microscope in normal adjustment.

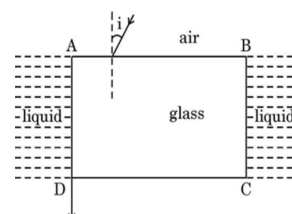
b) A thin pencil of length $(f/4)$ is placed coinciding with the principal axis of a mirror of focal length f . The image of the pencil is real and enlarged, just touches the pencil. Calculate the magnification produced by the mirror.
- a) A convex lens is placed in contact with a plane mirror. A point object at a distance of 20 cm on the axis of this combination has its image coinciding with itself. What is the focal length of the lens?

b) Calculate the angle of minimum deviation of an equilateral prism. The refractive index of the prism is $\sqrt{3}$. Calculate the angle of incidence for this case of minimum deviation also.
- a) Draw a schematic arrangement of a reflecting telescope (Cassegrain) showing how rays coming from a distant object are received at the eyepiece.

b) A ray of light is incident on a refracting face AB of a prism ABC at an angle of 45° . The ray emerges from face AC and the angle of deviation is 15° . The angle of prism is 30° . Show that the emergent ray is normal to the face AC from which it emerges out. Find the refractive index of the material of the prism.

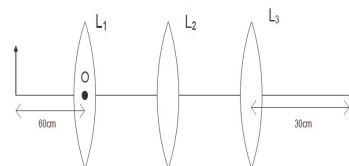
4. a) For the same value of angle of incidence, the angles of refraction in three media A, B and C are 15° , 25° and 35° respectively. In which medium would the velocity of light be minimum?

b) A rectangular glass slab ABCD ($n_1 = 1.5$) is surrounded by a transparent liquid ($n_2 = 1.25$) as shown in the figure. A ray of light is incident on face AB at an angle i such that it is refracted out grazing the face AD. Find the value of angle i .



5. a) An optical instrument uses eye-lens of power 20 D and the objective lens of power 50 D. Name the optical instrument and calculate its magnifying power if it forms the final image at infinity.

b) Three lenses L_1 , L_2 , L_3 each of focal length 30 cm are placed co-axially as shown in the figure. An object is held at 60 cm from the optic centre of Lens L_1 . The final real image is formed at the focus of L_3 . Calculate the separation between (i) (L_1 and L_3) and (ii) (L_2 and L_3).



6 Derive Lens maker's formula. Use it to show that a lens disappears in a medium of refractive index same as its own material

7 Draw a ray diagram to show refraction through a prism. Give prism formula. How it is modified for a thin prism? Draw graph to show variation of i with δ

8 Draw a ray diagram to show refraction at a convex spherical surface forming a virtual image. Write the refraction formula relating u , v and R if the light is going from (i) denser to rarer (ii) rarer to denser

9 A thin convex lens is made of material of refractive index ' n '. on the left side of lens medium has refractive index n_1 and to its right refractive index is n_3 . If $n_1 < n < n_3$ Draw a ray diagram to show image formation by it if object forms a real image. Hence establish relation among object distance (u), image distance (v) and radius of curvature (R)

10 For a glass prism, write the prism formula. In an astronomical telescope objective lens of focal length 150 cm and an eyepiece of focal length 6 cm are used.

(a) Calculate the magnifying power of the telescope in "normal adjustment."

(b) What is the length of the telescopic tube in this case?

A telescope has an objective lens of focal length 150 cm and an eyepiece of focal length 5 cm.

1. What is the magnifying power of the telescope?

2. If this telescope is used to view the moon, what is the diameter of the image of the moon formed by the objective lens?

(Given: The diameter of the moon is $3.6 \times 10^6 \text{ m}$ and radius of lunar orbit is $4 \times 10^8 \text{ m}$).

Answers

1. a) refer to the gist b) position of the other end $u = \frac{-7f}{4}$, $m = \frac{f}{f-u} = -4/3$

2. a) light rays from the object must fall on plane mirror normally. For this $f = u = 20 \text{ cm}$

- b) use prism formula to find $\delta = 60^\circ$ and then $i + e = A + \delta$ ($i = 60^\circ$)
3. a) refer to the gist b) $i + e = A + \delta \Rightarrow e = 0^\circ \Rightarrow r_2 = 0^\circ$
- 4.a) Use Snell's law and the relation, $n = \frac{\text{speed of light in vacu}}{\text{speed of light in th mediu}}$ (Ans: Medium A)
- b) Use the relation $\sin i_c = \frac{1}{n_{12}} = \frac{5}{6}$, $\sin r = \frac{\sqrt{11}}{6}$ Use Snell's law to find $i = \frac{\sqrt{11}}{4}$
5. a) Compound microscope, calculate f_0 . For image is at infinity, $m = \frac{D}{f_0}$
- b) Use lens law to find the image distance at first place, $v_1 = 60 \text{ cm}$, then the light rays must be parallel between L_2 and L_3 . Use this concept to find the answer. (i) $> 90 \text{ cm}$ (ii) any value
- 6 Formula: $1/f = (n_2/n_1 - 1)(1/R_1 - 1/R_2)$
- Condition: When $n_1 = n_2$, $(n_2/n_1 - 1) = 0$, so $1/f = 0$ and $f = \text{infinity}$.
- Final Result: The lens disappears as it behaves like a plane sheet of glass.
- 7 Prism Formula: $n = \sin[(A + D_m)/2] / \sin(A/2)$
- Thin Prism: $\delta = (n - 1)A$
- Graph: The i - δ curve shows deviation decreasing to a minimum (D_m) and then increasing.
- 8 (i) Denser to Rarer: $n_1/v - n_2/u = (n_1 - n_2)/R$
- (ii) Rarer to Denser: $n_2/v - n_1/u = (n_2 - n_1)/R$
- 9 Formula: $n/v_1 - n_1/u = (n - n_1)/R_1$
- Second Surface: $n_3/v - n/v_1 = (n_3 - n)/R_2$
- General Relation: $n_3/v - n_1/u = (n - n_1)/R_1 + (n_3 - n)/R_2$
- 10 1. Case 1 ($f_o = 150$, $f_e = 6$): $m = f_o/f_e = 150/6 = 25$; $L = f_o + f_e = 156 \text{ cm}$
2. Case 2 ($f_o = 150$, $f_e = 5$): $m = f_o/f_e = 150/5 = 30$
3. Moon Image: Angular size $\alpha = (3.6 \times 10^6) / (4 \times 10^8) = 0.009 \text{ rad}$
- Answer: Diameter of image $= \alpha * f_o = 0.009 * 150 = 1.35 \text{ cm}$

LONG ANSWER TYPE QUESTIONS-PRACTICE QUESTIONS

- An object is placed at a distance of 40 cm on the principal axis of a concave mirror of radius of curvature 30 cm. By how much distances do the images may move if the object is shifted through 15 cm?
- If you sit in a parked car, you glance in the rear-view mirror $R = 2 \text{ m}$ and notice a jogger approaching. If the jogger is running at a speed of 5 ms^{-1} , how fast is the image of jogger moving when the jogger is 39 m away.
- Four double convex lenses with following specification are available.

Lens	Focal length	Aperture	Lens	Focal length	Aperture
A	100 cm	10 cm	C	10 cm	2 cm
B	100cm	5 cm	D	5cm	2 cm

- Which of the given four lenses should be selected as objective and eyepiece to construct an astronomical telescope and why? What will be the magnifying power and length of the tube of this telescope?
- Draw ray diagram to show the working of a compound microscope. Deduce an expression for

magnifying power when the final image is formed at the near point. A compound microscope with an objective of 1.0cm focal length and an eye-piece of 2.0cm focal length has a tube of length of 20cm. Calculate the magnifying power of the microscope, if the final image is formed at the near point of the eye.

5. Draw a ray diagram to show the working of an astronomical telescope. Deduce an expression for magnifying power when the final image is formed at the near point. The magnifying power of an astronomical telescope in the normal adjustment is 20. If the length of the telescope is 105cm in this adjustment, find the focal lengths of the two lenses

ANSWERS

1. 13.5 cm 2. $\frac{1}{280}$ m/s 3. Eye lens-D, Objective lens- A, 20, 105 cm
4. $m = 270$ 5. 5 cm, 100 cm

CASE STUDY/PASSAGE-BASED QUESTIONS

1. A prism is a portion of a transparent medium bounded by two plane faces inclined to each other at a suitable angle. A ray of light suffers two refractions on passing through a prism and hence deviates through a certain angle from its original path. The angle of deviation of a prism is,

$$\delta = (\mu - 1) A,$$

Through which a ray deviates on passing through a thin prism of small refracting angle A. If μ

is refractive index of the material of the prism, then prism formula is, $\mu = \frac{\sin i \sin \left(\frac{A + \delta}{2} \right)}{\sin r \sin \left(\frac{A}{2} \right)}$

- (i) For which color, angle of deviation is maximum?

a) Red b) Yellow c) Violet d) Blue

- (ii) When white light moves in gravity free region

a) all colors have same speed b) different colors have different speeds
c) violet has more speed than red d) red has more speed than violet.

- (iii) The deviation through a prism is maximum when angle of incidence is

a) 45° b) 70° c) 90° d) 60°

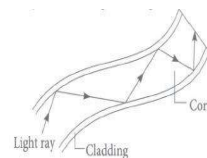
- (iv) What is the deviation produced by a prism of angle 6° ? (Refractive index of the material of the prism is 1.644).

a) 3.864° b) 4.595° c) 7.259° d) 1.252°

- (v) A ray of light falling at an angle of 50° is refracted through a prism and suffers minimum deviation. If the angle of prism is 60° , then the angle of minimum deviation is

a) 45° b) 75° c) 50° d) 40°

2. An optical fibre is a thin tube of transparent material that allows light to pass through, without being refracted into the air or another external medium. It make use of total internal reflection. These fibres are fabricated in such a way that light reflected at one side of the inner surface strikes the other at an angle larger than critical angle. Even, if fibre is bent, light can easily travel along the length.



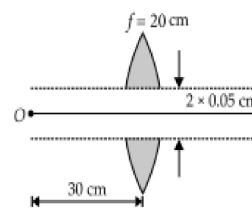
- (i) Which of the following is based on the phenomenon of total internal reflection of light?

a) Sparkling of diamond b) Optical fibre communication
c) instrument used by doctors for endoscopy d) All of these

- (ii) A ray of light will undergo total internal reflection inside the optical fibre, if it

- a) goes from rarer medium to denser medium
 - b) is incident at an angle less than the critical angle
 - c) strikes the interface normally
 - d) is incident at an angle greater than the critical angle
- (iii) If in core, angle of incidence is equal to critical angle, then angle of refraction will be
- a) 0°
 - b) 45°
 - c) 90°
 - d) 180°
- (iv) In an optical fibre correct relation for refractive indices of core (n_1) and cladding (n_2) is
- a) $n_1 = n_2$
 - b) $n_1 > n_2$
 - c) $n_1 < n_2$
 - d) $n_2 = 2$
- (v) If the value of critical angle is 30° for total internal reflection from given optical fibre, then speed of light in that fibre is
- a) 10^8 m s^{-1}
 - b) $1.5 \times 10^8 \text{ m s}^{-1}$
 - c) $6 \times 10^8 \text{ m s}^{-1}$
 - d) $4.5 \times 10^8 \text{ m s}^{-1}$
- 3.** The lens maker's formula relates the focal length of a lens to the refractive index of the lens material and the radii of curvature of its two surfaces. This formula is called so because it is used by manufacturers to design lenses of required focal length from a glass of given refractive index. If the object is placed at infinity, the image will be formed at focus for both double convex lens and double concave lens
- Therefore, lens maker's formula is $\frac{\mu_2}{f} = (\mu_2 - \mu_1) \left[\frac{1}{R_1} - \frac{1}{R_2} \right]$
- (i) The radius of curvature of each face of biconcave lens with refractive index 1.5 is 30 cm. The focal length of the lens in air is
- a) 12cm
 - b) 10cm
 - c) 20 cm
 - d) 30 cm
- (ii) The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. If focal length is 12 cm, then refractive index of glass is
- a) 1.5
 - b) 1.78
 - c) 2.0
 - d) 2.52
- (iii) An under-water swimmer cannot see very clearly even in absolutely clear water because of
- a) absorption of light in water
 - b) scattering of light in water
 - c) reduction of speed of light in water
 - d) change in the focal length of eye-lens
- (iv) A thin lens of glass ($\mu = 1.5$) of focal length 10 cm is immersed in water ($\mu = 1.33$). The new focal length is
- a) 20cm
 - b) 40cm
 - c) 48cm
 - d) 12cm
- (v) An object is immersed in a fluid. In order that the object becomes invisible, it should
- a) behave as a perfect reflector
 - b) absorb all light falling on it
 - c) have refractive index one
 - d) have refractive index exactly matching with that of the surrounding fluid.
- 4.** A convex or converging lens is thicker at the center than at the edges. It converges a parallel beam of light on refraction through it. It has a real focus. A convex lens is of three types :
- (i) Double convex lens
 - (ii) Plano-convex lens
 - (iii) Concavo-convex lens. The concave lens is thinner at the center than at the edges. It diverges a parallel beam of light on refraction through it. It has a virtual focus.

- (i): A point object O is placed at a distance of 0.3 m from a convex lens (focal length 0.2 m) cut into two halves each of which is displaced by 0.05 m as shown in the figure.



- What will be the location of the image?
- a) 30 cm right of lens b) 60 cm right of lens
c) 70 cm left of lens d) 40 cm left of lens
- (ii) Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, the focal length of the other would be.
- a) -26.7 cm b) 60 cm c) -80 cm d) 20 cm
- (iii) A spherical air bubble is embedded in a piece of glass. For a ray of light passing through the bubble, it behaves like a
- a) converging lens b) diverging lens c) plano-converging lens d) plano-diverging lens
- (iv) Lens used in magnifying glass is
- a) Concave lens b) Convex lens
c) Both (a) and (b) d) Neither concave lens nor convex lens
- (v) The magnification of an image by a convex lens is positive only when the object is placed
- a) at its focus F b) between F and 2F c) at 2F d) between F and optical center

Answers

1. i. c) $\text{Deviation} \propto \frac{1}{\text{wavelength}}$ ii. a) a gravity-free region is essentially a vacuum for the purpose of light propagation
iii. c) The deviation is maximum when the ray either just enters the prism (grazing incidence) or just exits the prism (grazing emergence).
iv. a) use formula $\delta = (\mu - 1) A$
v. d) use formula $i + e = \delta + A$
2. i. d) ii. d) iii. c) iv. c) For TIR, light must travel from a denser medium to a rarer medium v. b) Using formula $\sin i_c = \frac{1}{n_{21}}$ and then use Snell's formula
3. i. d) use lens formula to calculate focal length
ii. a) use lens formula to calculate refractive index
iii. d) The difference in refractive index between the water and the cornea is very small. This significantly reduces the refractive power of the cornea, making it difficult for the eye to converge light rays sufficiently to form a clear image on the retina.
iv. b) use lens maker's formula to calculate new focal length v. d)
4. i. b) use lens formula to calculate image distance ii. a) use the formula $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$
iii. b) A spherical air bubble within glass acts as a diverging lens because the light rays moving from glass to air bend away from the normal, and then when moving from air to glass, they bend towards the normal again, resulting in an overall divergence of the light rays.
iv. b) convex lens produce a magnified, virtual, and erect image of an object
v. d) Ray diagrams may be drawn to locate the position of object

CASE STUDY/PASSAGE-BASED PRACTICE QUESTIONS

- 1 On a bright sunny day a student burns a paper by using a convex lens (refractive index 1.5) by keeping it 40 cm away from the lens. Now he dips the lens in a glass filled with a liquid. He repeats the act by bringing it closer to the paper time and again but could not

succeed. His teacher was observing him and suggested that he must move away from the paper rather than coming closer to it. He follows his teacher and performs the activity. for a particular distance 'd' he could burn the paper again.

(i) The focal length of the lens in air is

(a) 20cm (b) 40cm (c) 60cm (d) 80cm

(ii) if the value of 'd' is 2m the refractive index of the liquid is nearly

(a) 1.36 (b) 1.45 (c) 1.5 (d) 1.68

(iii) The behaviour of the lens in the liquid is like a

(a) prism (b) concave lens (c) glass slab (d) convex lens

(iv) If he uses a lens of bigger aperture but same material and same radii of curvature the value of 'd' for which he could burn the paper will be

(a) $d > 2m$ (b) $d < 2m$ (c) $d = 2m$ (d) depending on size of aperture

2 A compound microscope is an optical instrument used for observing highly resolved and magnified images of tiny objects which are placed very close to it. Magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final image to the angle subtended at the eye by the object, when both the final image and the objects are situated at the least distance of distinct vision from the eye. It can be given that: $m = m_e \times m_o$, where m_e is the magnification produced by the eye lens and m_o is the magnification produced by the objective lens. Consider a compound microscope that consists of an objective lens of focal length 2.0 cm and an eyepiece of focal length 6.25 cm separated by a distance of 15 cm.

(i) The object distance for eye-piece, so that final image is formed at the least distance of distinct vision, will be

(a) 3.45 cm (b) 5 cm (c) 1.29 cm (d) 2.59 cm

(ii) How far from the objective should an object be placed in order to obtain the condition described in part (i)?

(a) 4.5 cm (b) 2.5 cm (c) 1.5 cm (d) 3.0 cm

(iii) What is the magnifying power of the microscope in case of least distinct vision?

(a) 20 (b) 30 (c) 40 (d) 50

(iv) The intermediate image formed by the objective of a compound microscope is

(a) real, inverted and magnified (b) real, erect and magnified
(c) virtual, erect and magnified (d) virtual, inverted and magnified

OR

The magnifying power of a compound microscope increases with

(a) the focal length of objective lens is increased and that of eye lens is decreased.
(b) the focal length of eye lens is increased and that of objective lens is decreased.
(c) focal length of both objects and eye-piece are increased.
(d) focal length of both objects and eye-piece are decreased.

3. As we know, when light ray travels from one medium to another changes its direction of path due to the change in optical density of the medium. When light ray travels from optically denser medium to the optically rarer medium then some of the light get reflected back in the same medium and remaining light get refracted in the second medium and such a phenomenon

of light is called as internal reflector light. We know that when a ray of light travels from denser medium to rarer medium then it get bent away from the normal. If we increase the angle of incidence slowly then angle of refraction also get increased and at one stage, the angle of refraction is 90° for some angle of incidence. And further if we increase the angle of incidence then there will be no refraction of light, and the ray will be totally internally reflected. Such phenomenon of reflection of light is called as total internal reflection of light. And the angle of incidence in denser medium for which the angle of refraction in rarer medium is 90° , that angle of incidence is called as critical angle. So we define total internal reflection as if the angle of incidence exceeds the critical angle, then the total light get internally reflected. Mirage is the best real-life example of total internal reflection of light. The high brilliance of diamonds is only due to the total internal reflection of light through them which is get total internally reflected many times and causes brilliance of diamonds. Prisms are also made by using total internal reflection of light. We all know that, optics is the vast branch of physics which has vast application in our daily life such as optical fibre. Optical fibre are used for long distance transmission of audio and video signal also. And they are mainly constructed on the basis of total internal reflection of light to reduce the decrease in amplitude of the sending signal.

- i) For critical angle the value of corresponding angle of refraction is ____
 a) 180° b) less than 90° c) greater than 90° d) 90°
- ii) As the refractive index of the medium increases the corresponding value of critical angle for that medium ____
 a) decreases b) increases
 c) remains same d) independent of refractive index of the medium
- iii) In case of total internal reflection, for angle of incidence greater than critical angle the refraction of light is not possible because ____
 a) Snell's law of refraction get satisfied b) Snell's law of refraction cannot be satisfied
 c) laws of refraction cannot be satisfied d) can't say
- iv) What is mean by optically denser and optically rarer medium?

OR

How would total internal reflection of light be possible in case of optical fibres?

Answers

- | | | | |
|--------------------|------------------|---|-------------------|
| 1 i) b | ii) a | iii) d | iv) c |
| 2 i) b | ii) b | iii) b | iv) a OR d |
| 3 i) d) 90° | ii) a) decreases | iii) b) Snell's law of refraction cannot be satisfied | |