INDIAN SCHOOL AL WADI AL KABIR

CLASS: XII	**DEPARTMENT: SCIENCE 2024 -25** **SUBJECT: PHYSICS**	**DATE: 25.10.2024**
WORKSHEET No: 8 **WITH ANSWERS**	**Topic: RAY OPTICS AND OPTICAL INSTRUMENTS**	**NOTE: A4 FILE FORMAT**
CLASS & SEC:	**NAME OF THE STUDENT:**	**ROLL NO:**

Multiple choice questions:

1. The focal lengths of objective and the eyepiece of a compound microscope are 1 cm and 2 cm respectively. If the tube length of the microscope is 10 cm, the magnification obtained by the microscope for most suitable weaving by relaxed eye is.
   (a) 250 (b)200 (c) 150 (d) 125
2. The minimum distance between an object and its real image formed by a convex lens of focal length f is:
   (a) f (b) 2f (c) 3f (d) 4f
3. A ray of monochromatic lights propagating in air is incident on the surface of water. Which of the following will be the same for the reflected and refracted rays?
   (a) energy carried (b) speed
   (c) frequency (d) wavelength.
4. A biconcave lens of power P vertically splits into two identical plano-concave parts. The power of each part will be,
   (a) 2P (b) P/2 (c) P (d) $P/\sqrt{2}$
5. A converging lens is used to form an image on a screen. When the upper half of the lens is covered by an opaque screen.
   (a) half the image will disappear. (b) incomplete image will be formed.
   (c) intensity of image will decrease but complete image is formed.
   (d) intensity of image will increase but image is not distinct.
6. In optical fibres, the refractive index of the core is
   (a) greater than that of the cladding. (b) equal to that of the cladding.
   (c) smaller than that of the cladding. (d) independent of that of cladding.
7. Air bubble in water behaves as
   (a) sometimes concave, sometimes convex lens (b) concave lens
   (c) convex lens (d) always refracting surface
8. We combine two lenses, one is convex and other is concave having focal lengths f_1, and f_2 and their combined focal length is F. Combination of the lenses will behave like concave lens, if
   (a) $f_1 > f_2$ (b) $f_1 = f_2$ (c) $f_1 < f_2$. (d) $f_1 \leq f_2$
9. The focal length of a biconvex lens of radii of each surface 50 cm and refractive index 1.5, is
   (a) 40.4 cm (b) 75 cm (c) 50 cm (d) 80 cm
10. A metal coin is at bottom of a beaker filled with a liquid of refractive index = 4/3 to height of 6 cm. To an observer looking from above the surface of liquid, coin will appear at a depth
    (a) 1.5 cm (b) 6.75 cm (c) 4.5 cm (d) 7.5 cm
11. Two lenses of focal lengths ± 15 cm and ± 150 cm are available for making a telescope. To produce the largest magnification, the focal length of the eyepiece should be

(a) + 15 cm (b) + 150 cm (c) – 150 cm (d) – 15 cm

12. The refractive index of the material of an equilateral prism is √3. What is the angle of minimum deviation?

(a) 45° (b) 60° (c) 37° (d) 30°

13. A convex lens of refractive index 3/2 has a power of 2.5 D in air. If it is placed in a liquid of refractive index 2 then the new power of the lens is

(a) – 1.25 D (b) – 1.5 D (c) 1.25 D (d) 1.5 D

14. A double convex lens of refractive index μ_1 is immersed in a liquid of refractive index μ_2. The lens will act as transparent plane sheet when

(a) $\mu_1 = \mu_2$ (b) $\mu_1 > \mu_2$ (c) $\mu_1 < \mu_2$ (d) $\mu_1 = 1/\mu 2$

15. When a ray of light enters from one medium to another, then which of the following does not change?

(a) Frequency (b) Wavelength (c) Speed (d) Amplitude

Ans -1. (d), 2. (d), 3. (c), 4. (a), 5. (c),6. (a), 7. (b), 8. (a), 9. (c), 10. (c), 11. (a), 12. (b), 13. (a), 14. (a), 15. (a)

Assertion and reason type questions: -

(A) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

(B) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(C) Assertion (A) is true, but Reason (R) is false.

(D) Assertion (A) is false and Reason (R) is also false.

1. Assertion (A): The magnifying power of a compound microscope is negative.
Reason (R): The final image formed is erect with respect to the object.

(A) A (B) B (C) C (D) D

2. Assertion (A): A convex lens, when immersed in a liquid, disappears.
Reason (R): The refractive indices of material of the lens and the liquid are equal.

(A) A (B) B (C) C (D) D

Ans; 1.C, 2. A

Case-Study Based Questions:

1. A lens is a transparent medium bounded by two surfaces, with one or both surfaces being spherical. The focal length of a lens is determined by the radii of curvature of its two surfaces and the refractive index of its medium with respect to that of the surrounding medium. The power of a lens is reciprocal of its focal length. If a number of lenses are kept in contact, the power of the combination is the algebraic sum of the powers of the individual lenses.

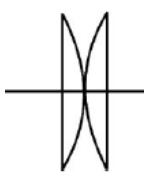
(i) A double-convex lens, with each face having same radius of curvature R, is made of glass of refractive index n. Its power is:

(A) $\frac{2(n-1)}{R}$ (B) $\frac{(2n-1)}{R}$ (C) $\frac{(n-1)}{2R}$ (D) $\frac{(2n-1)}{2R}$

(ii) A double-convex lens of power P, with each face having same radius of curvature, is cut into two equal parts perpendicular to its principal axis. The power of one part of the lens will be:

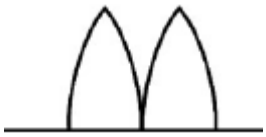
(A) 2P (B) P (C) 4P (D) $\frac{P}{2}$

(iii) The above two parts are kept in contact with each other as shown in the figure. The power of the combination will be:



(A) $\frac{P}{2}$ (B) P (C) 2P (D) $\frac{P}{4}$

(iv) (a) A double-convex lens of power P, with each face having same radius of curvature, is cut along its principal axis. The two parts are arranged as shown in the figure. The power of the combination will be:



(A) 0 (B) P (C) 2P (D) $\frac{P}{4}$

OR

(b) Two convex lenses of focal lengths 60 cm and 20 cm are held coaxially in contact with each other. The power of the combination is:

(A) 6·6 D (B) 15 D (C) $\frac{1}{15}$ D (D) $\frac{1}{80}$ D

Ans: - (i) (A) $\frac{2(n-1)}{R}$ (ii) (D) P/2 (iii) (B) P (iv) (a) (C) 2P OR (b) (A) 6.6 D

2. When a ray of light propagates from a denser medium to a rarer medium, it bends away from the normal. When the incident angle is increased, the refracted ray deviates more from the normal. For a particular angle of incidence in the denser medium, the refracted ray just grazes the interface of the two surfaces. This angle of incidence is called the critical angle for the pair of media involved.

(i) For a ray incident at the critical angle, the angle of reflection is:

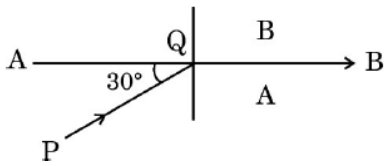
(A) 0 (B) < 90° (C) > 90° (D) 90°

(ii) A ray of light of wavelength 600 nm is incident in water (n = 4/3) on the water-air interface at an angle less than the critical angle. The wavelength associated with the refracted ray is:

(A) 400 nm (B) 450 nm (C) 600 nm (D) 800 nm

(iii)

(a) The interface AB between the two media A and B is shown in the figure. In the denser medium A, the incident ray PQ makes an angle of 30 with the horizontal. The refracted ray is parallel to the interface. The refractive index of medium B w.r.t. medium A is:



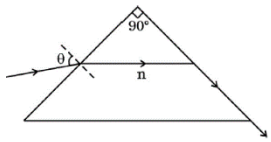
(A) $\sqrt{3}$ /2 (B) $\sqrt{5}$ /2 (C) 4 / $\sqrt{3}$ (D) 2 / $\sqrt{3}$

OR

(b) Two media A and B are separated by a plane boundary. The speed of light in medium A and B is 2 x 10^8 m/s and 2·5 x 10^8 m/s respectively. The critical angle for a ray of light going from medium A to medium B is:

(A) $\sin^{-1}\left(\frac{1}{2}\right)$ (B) $\sin^{-1}\left(\frac{4}{5}\right)$ (C) $\sin^{-1}\left(\frac{3}{5}\right)$ (D) $\sin^{-1}\left(\frac{2}{5}\right)$

(iv) The figure shows the path of a light ray through a triangular prism. In this phenomenon, the angle is given by:



(A) $\sin^{-1}(\sqrt{n^2-1})$ (B) $\sin^{-1}(n^2-1)$

(C) $\sin^{-1}\left(\frac{1}{\sqrt{n^2-1}}\right)$ (D) $\sin^{-1}\left(\frac{1}{n^2-1}\right)$

Ans; - (i) (D) 6 (ii) (C) 3 (iii) (a) (C) 6 OR (b) $\sin^{-1}(0.225)$ (iv) (D) 10

2 marks questions.

1. Monochromatic light of frequency 5·0 ×10^{14} Hz passes from air into a medium of refractive index 1·5. Find the wavelength of the light (i) reflected, and (ii) refracted at the interface of the two media.

(i)

$v = \upsilon \lambda$

$3\times10^{8} = 5\times10^{14} \times \lambda$

$\lambda = 600$ nm or 6×10^{-7}m

(ii)

$$\lambda_{medium} = \frac{\lambda_{air}}{\mu}$$

$$\lambda_{medium} = \frac{600\,nm}{1.5}$$

$= 400$ nm or 4×10^{-7}m

2. A plano-convex lens of focal length 16 cm is made of a material of refractive index 1.4. Calculate the radius of the curved surface of the lens.

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

$$\frac{1}{16} = (1.4 - 1)\left(\frac{1}{R} - \frac{1}{\infty}\right)$$

$$\frac{1}{16} = 0.4 \times \frac{1}{R}$$

$R = 16 \times 0.4$

$R = 6.4$ cm

3. An object is placed 30 cm in front of a concave mirror of radius of curvature 40 cm. Find the (i) position of the image formed and (ii) magnification of the image.

(i) $\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$

$\frac{1}{v} + \frac{1}{-30} = \frac{1}{-20}$

On solving

$v = -60$ cm

(ii) $m = -\frac{v}{u}$

$= -\left(\frac{-60}{-30}\right)$

$= -2$

4. A convex lens (n = 1·52) has a focal length of 15·0 cm in air. Find its focal length when it is immersed in liquid of refractive index 1·65. What will be the nature of the lens?

$$\frac{1}{f_l} = \left(\frac{n_g}{n_l} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{f_l}{f_a} = \frac{\frac{1.52-1}{1}}{\frac{1.52-1.65}{1.65}}$$

$= -6.6$

$f_l = -6.6\, f_a$

$= -99$cm

Nature of the lens: Diverging/ behaves like a concave lens.

5. The magnifying power of an astronomical telescope is 24. In normal adjustment, distance between its two lenses is 150 cm. Find the focal length of the objective lens.

Magnifying power = 24 , Distance between lenses =150 cm

$$\frac{f_o}{f_e} = 24$$

$$f_o + f_e = 150\,\text{cm}$$

$$f_e = 6\,\text{cm}$$

$$f_o = 144\,\text{cm}$$

3 marks questions

1. A ray of monochromatic light passes from medium (1) to medium (2). If the angle of incidence in medium (1) is θ and the corresponding angle of refraction in medium (2) is θ/2, which of the two media is optically denser? Give reason.

Given: $i = \theta, r = \frac{\theta}{2}$

$$\because \quad \frac{\sin i}{\sin r} = \frac{n_2}{n_1}$$

i.e. $\sin r < \sin i \Rightarrow n_2 > n_1$

Hence, 2nd medium is optically denser.

2. 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?

Explanation:

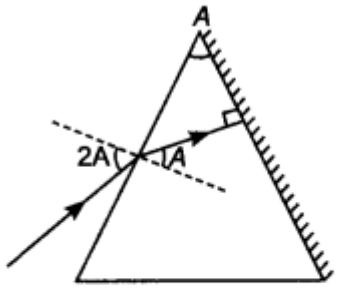
$$\because \quad n = \frac{\sin i}{\sin r} = \frac{c}{v}$$

Thus, the medium for which angle of refraction is of 15°, the speed of light is minimum

3. A ray of light incident on one of the faces of a glass prism of angle A has angle of incidence 2A. The refracted ray in the prism strikes the opposite face which is silvered, the reflected ray from it retracing its path. Trace the ray diagram and find the relation between the refractive index of the material of the prism and the angle of the prism.

Explanation:

Given: i = 2 A, r = 90° – (90° – A) = A



$$n = \frac{\sin i}{\sin r} = \frac{\sin 2A}{\sin A}$$

$$= \frac{2 \sin A \cos A}{\sin A}$$

∴ n = 2 cos A

4. Does the magnifying power of a microscope depend on the colour of the light used? Justify your answer.
Magnifying power of a microscope,

$$m = -\frac{L}{f_o}\left(1+\frac{D}{f_e}\right)$$

Since the focal length of a convex lens depends on the refractive index, and refractive indices for different colours are different, so according to the lens maker's formula

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

The magnifying power of a microscope depends on the colour of the light used

5. The refractive index of the material of a prism is $\sqrt{2}$. If the refracting angle of the prism is 60, find the (1) Angle of minimum deviation, and (2) Angle of incidence.

(1) $$\mu = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$$

$$\sqrt{2} = \frac{\sin\left(\frac{60+\delta_m}{2}\right)}{\sin 30^\circ}$$

$$\Rightarrow \sin\left(\frac{60+\delta_m}{2}\right) = \frac{1}{\sqrt{2}} = \sin 45^\circ$$

$$\frac{60+\delta_m}{2} = 45^\circ \Rightarrow \delta_m = 30^\circ$$

(2) $$i = \frac{A+\delta_m}{2}$$

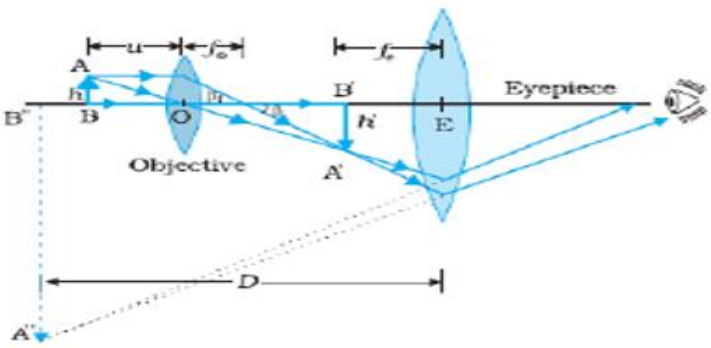
$$\Rightarrow i = \frac{60+30}{2}$$

$$i = 45^\circ$$

5 marks questions

1.(i) Draw a labelled ray diagram of a compound microscope showing image formation at least distance of distinct vision. Derive an expression for its magnifying power.
(ii) A telescope consists of two lenses of focal length 100 cm and 5 cm. Find the magnifying power when the final image is formed at infinity.

(i)



The magnification obtained by eye-piece lens $m_e = \left(1+\frac{D}{f_e}\right)$

The magnification obtained by objective lens $m_0 = \frac{v_0}{-u_0}$

Hence the total magnifying power is

$$m = m_0 \times m_e$$

$$= \frac{v_0}{-u_0}\left(1+\frac{D}{f_e}\right)$$

(ii) $m = \left|\frac{f_0}{f_e}\right|$

Identification of focal length of objective and eyepiece

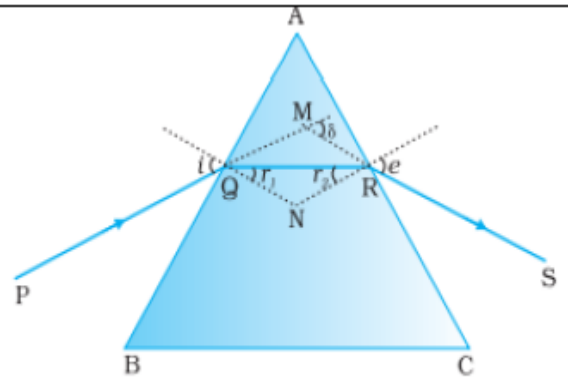
$f_0 = 100cm$

$f_e = 5cm$

$m = \left|\frac{100}{5}\right| = 20$

2. (i) Trace the path of a ray of light showing refraction through a triangular prism and hence obtain an expression for angle of deviation (δ) in terms of A, i and e, where symbols have their usual meanings. Draw a graph showing the variation of angle of deviation with the angle of incidence.
(ii) In the figure, a ray of light is incident on a transparent liquid contained in a thin glass box at an angle of 45° with its one face. The emergent ray passes along the face AB. Find the refractive index of the liquid.

(i)



For quadrilateral AQNR,

$\angle A + \angle QNR = 180°$ --- (i)

For triangle QNR

$r_1 + r_2 + \angle QNR = 180°$ ---- (ii)

comparing equation (i) and (ii)

$r_1 + r_2 = A$ ------ (iii)

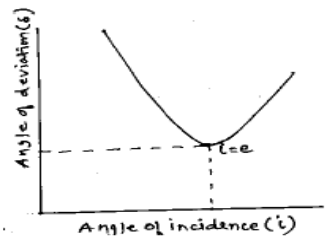
The angle of deviation

$\delta = (i - r_1) + (e - r_2)$ ------ (iv)

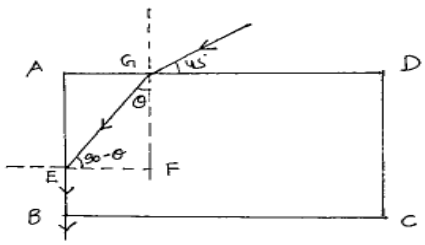
from equation (iii) and (iv)

$\delta = i + e - A$

Graph



(ii)



$\frac{\sin 45°}{\sin \theta} = \mu$

$\frac{1}{\sqrt{2}} = \mu \sin \theta$

For second surface,

$\frac{1}{\sqrt{2}} \frac{\cos \theta}{\sin \theta} = 1$

$\tan \theta = \frac{1}{\sqrt{2}}$

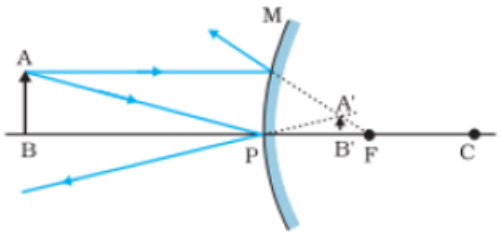
From the triangle GEF

$\sin \theta = \frac{1}{\sqrt{3}}$

$\mu = \sqrt{\frac{3}{2}}$

3. (i) Draw a diagram for the formation of the image of an object by a convex mirror, hence obtain the mirror equation.
(ii) Why are multi component lenses used for both objective and the high peaks in optical instruments?
(iii) The magnification of a small object produced by a compound microscope is 200. The focal length of the eyepiece is 2 cm and the final image is formed at Infinity. Find the magnification produced by the objective.

i)



For paraxial rays MP can be considered to be a straight line perpendicular to CP,
Therefore right angled triangles $A'B'F$ and MPF are similar

$$\frac{B'A'}{PM} = \frac{B'F}{FP}$$

Or $\frac{B'A'}{BA} = \frac{B'F}{FP}$ ($\because$ PM = AB) ----------(1)

Since $\angle$ APB = $\angle$ $A'PB'$, the right angled triangles $A'PB'$ and ABP are also similar

Therefore , $\frac{B'A'}{BA} = \frac{B'P}{BP}$ ---------- (2)

Comparing eq (1) and (2), we get

$$\frac{B'F}{FP} = \frac{B'P}{BP}$$

$$\frac{PF-PB'}{FP} = \frac{B'P}{BP}$$

Using sign convention

PF = f, PB'= +v , PB =-u

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

ii) To improve image quality by minimizing various optical aberrations in lenses.

iii) Magnification produced by compound microscope

$$m = m_o \times m_e$$

$$m_o = \frac{m}{m_e} = \frac{m}{\left|\frac{D}{fe}\right|}$$

$$m_o = \frac{200}{\frac{25}{2}} = 16$$

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