Optics

AIPMT- 2012

1. **When a biconvex lens of glass having refractive index 1.47 is dipped in a liquid, it acts as a plane sheet of glass. This implies that the liquid must have refractive index**

a) Equal to that of glass   b) Less than one

c) Greater than that of glass   d) Less than that of glass

2. **A ray of light is incident at an angle of incidence i, on one face of a prism of angle A (assumed to be small) and emerges normally from the opposite face. If the refractive index of the prism is μ, the angle of incidence i, is nearly equal to**

a) μA b) $\frac{\mu A}{2}$ c) $\frac{A}{\mu}$ d) $\frac{A}{2\mu}$

3. **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) $-f_1+f_2$ c) $2f_1+f_2$ d) $-2f_1+f_2$

4. **The magnifying power of a telescope is 9. When it is adjusted for parallel rays the distance between the objective and eyepiece is 20 cm. The focal lengths of lenses are**

a) 10 cm, 10 cm   b) 15 cm, 5 cm   c) 18 cm, 2 cm   d) 11 cm, 9 cm

5. For the angle of minimum deviation of a prism to be equal to its refracting angle, the prism must be made of a material whose refractive index

a) Lies between $\sqrt{2}$ and 1 b) Lies between 2 and $\sqrt{2}$

c) Is less than 1 d) Is greater than 2

6. A rod of length 10cm lies along the principal axis of a concave mirror of focal length 10cm in such a way that its end closer to the pole is 20cm away from the mirror, the length of the image is

a) 10 cm b) 15 cm c) 2.5 cm d) 5 cm

2011

7. Which of the following is not due to total internal reflection?

a) Working of optical fiber

b) Difference between apparent and real depth of a pond

c) Mirage on hot summer days

d) Brilliance of diamond

8. A biconvex lens has a radius of curvature of magnitude 20cm. Which one of the following options describes best the image formed of an object of height 2 cm placed 30cm from the lens?

a) Virtual, upright, height = 4 cm b) Virtual, upright, height = 1 cm

c) Real, inverted, height = 4cm d) Real, inverted, height = 1cm

9. **A thin prism of angle 150^0 made of glass of refractive index μ_1=1.5 is combined with another prism of glass of refractive index μ_1=1.75. The combinations of the prisms produce dispersion without deviation. The angle of the second prism should be**

a) 5^0 b) 7^0 c) 10^0 d) 12^0

10. **A converging beam of rays is incident on a diverging lens. Having passed through the lens the rays intersect a point 15 cm from the lens on the opposite side. If the lens is removed the point where the rays meet will move 5 cm closer to the lens. The focal length of the lens is**

a) 5 cm b) -10 cm c) 20 cm d) -30 cm

2010

11. **A ray of light travelling in a transparent medium of refractive index μ, falls on a surface separating the medium from air at an angle of incidence of 45^0. For which of the following value of μ the ray can undergo total internal reflection?**

a) μ = 1.33 b) μ=1.40 c) μ=1.50 d) μ=1.25

12. **A lens having focal length f and aperture of diameter d forms an image of intensity I. Aperture of diameter d/2 in central region is covered by a black paper. Focal length of lens and intensity of image now will be respectively.**

a) f and $\frac{I}{4}$ b) $\frac{3f}{4}$ and $\frac{I}{2}$ c) f and $\frac{3I}{4}$ d) $\frac{f}{2}$ and $\frac{I}{2}$

13. **The speed of light in media M_1 and M_2 are 1.5 x 10^8 m/s and 2.0 x 10^8 m/s respectively. A ray of light enters from medium M_1 to M_2 at an incidence angle i. If the ray suffers total internal reflection, the value of i is**

a) Equal to $\sin^{-1}\left(\frac{2}{3}\right)$
b) Equal to or less than $\sin^{-1}\left(\frac{3}{5}\right)$
c) Equal to or greater than $\sin^{-1}\left(\frac{3}{4}\right)$
d) Less than $\sin^{-1}\left(\frac{2}{3}\right)$

14. **A ray of light is incident on a 60^0 prism at the minimum deviation position. The angle of refraction at the first face (i.e., incident face) of the prism is**

a) Zero b) 30^0 c) 45^0 d) 60^0

Key

1. a	**2. a**	**3.c**	**4.c**	**5.b**	**6.d**	**7.b**
8. c	**9.c**	**10.d**	**11.c**	**12.c**	**13.c**	**14.b**

Solutions

1. (a) According to lens maker's formula

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

Where μ_g is the refractive index of the material of the lens and μ_L is the refractive index of the liquid in which lens is dipped.

As the biconvex lens dipped in a liquid acts as a plane sheet of glass, therefore

$$f = \infty \Rightarrow \frac{1}{f} = 0$$

$$\therefore \frac{\mu_g}{\mu_L} - 1 = 0 \text{ Or } \mu_g = \mu_L$$

2. (a)

As the emergent ray emerges normally from the opposite face,

$\therefore$ e = 0, $r_2 = 0$

As $r_1 + r_2 = A \Rightarrow r_1 = A$

Applying Snell's law for incident ray

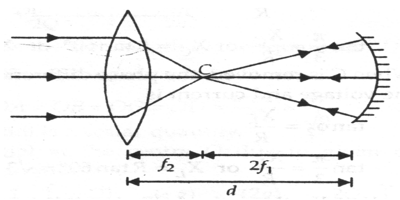
$$\sin i = \mu \sin r_1 = \mu \sin A$$

Or $\mu = \frac{\sin i}{\sin A}$ [Let $i = i_1$]

For small angle, $\sin i \approx I$, $\sin A \approx A$

$\therefore \mu = \frac{i}{A}$ Or $i = \mu A$

3. (c)



$\therefore d = 2f_1 + f_2$

4. (c)

Magnifying power $m = \frac{f_0}{f_e} = 9$ …….. (i)

Where f_0 and f_e are the focal lengths of the objective and eyepiece respectively

Also, $f_0 + f_e$ = 20 cm …….. (ii)

On solving (i) and (ii), we get

f_0 = 18 cm, f_e = 2 cm

5. (b)

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

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

$$= \frac{2\sin\left(\frac{A}{2}\right)\cos\left(\frac{A}{2}\right)}{\sin\left(\frac{A}{2}\right)} = 2\cos\left(\frac{A}{2}\right)$$

As $\delta = i + e - A$

At minimum deviation, $\delta = \delta_m$, i=e

$\therefore \delta_m = 2i - A$

$2i = \delta_m + A$

$i = \dfrac{\delta_m + A}{2}$

$= \dfrac{A+A}{2} = A(\because \delta_m = A(\text{given}))$

$\because i_{\min} = 0^0 \Rightarrow A_{\min} = 0^0$

Then,

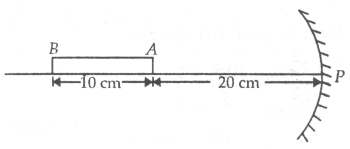
$\mu_{\min} = 2\cos 0^0 = 2$

$\therefore i_{\min} = \dfrac{\pi}{2} \Rightarrow A_{\max} = \dfrac{\pi}{2}$

Then,

So refractive index lies between 2 and $\sqrt{2}$

6. (d)



Here, f = -10 cm

For end A, u_A = -20 cm

Image position of end A,

$$\frac{1}{\upsilon_A}+\frac{1}{u_A}=\frac{1}{f}$$

$$\frac{1}{\upsilon_A}+\frac{1}{(-20)}=\frac{1}{(-10)} \text{ or } \frac{1}{\upsilon_A}=\frac{1}{-10}+\frac{1}{20}=-$$

υ_A = - 20 cm

For end B, u_B=-30 cm

Image position of end B,

$$\frac{1}{\upsilon_B}+\frac{1}{(-30)}=\frac{1}{(-10)} \text{ Or } \frac{1}{\upsilon_B}=\frac{1}{-10}+\frac{1}{30}=-\frac{2}{30}$$

υ_B= -15 cm

Length of the image

$$|\upsilon_A|-|\upsilon_B|=20cm-15cm=5cm$$

7. (b) Difference between apparent and real depth of a pond is due to refraction. Other three are due to total internal reflection.

8 (c) Let $\mu=\frac{3}{2}$

According to lens maker's formula

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

For biconvex lens, R_1 = +20 cm, R_2 = -20 cm

$$\therefore \frac{1}{f}=\left(\frac{3}{2}-1\right)\left(\frac{1}{20}+\frac{1}{20}\right)=\frac{1}{20} \text{ or f = 20 cm}$$

According to thin lens formula

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

Here, u = -30 cm

$$\therefore \frac{1}{20}=\frac{1}{\upsilon}-\frac{1}{-30} \Rightarrow \frac{1}{\upsilon}=\frac{1}{20}-\frac{1}{30}$$

υ = 60 cm

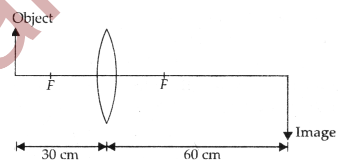
The image is formed at a distance of 60cm on the right hand side of the lens. It is a real image.

Magnification, $m=\frac{\upsilon}{u}=\frac{h_I}{h_0}$

$$\frac{60cm}{-30cm}=\frac{h_1}{2cm} \Rightarrow h_1 = -4cm$$

-ve sign shows that image is inverted.

The image is real, inverted and height of 4 cm as shown in figure.



9. (c) For dispersion without deviation

$$\delta_1+\delta_2=0$$

$$(\mu_1-1)A_1+(\mu_2-1)A_2=0$$

$$A_2=\frac{(\mu_1-1)A_1}{(\mu_2-1)}$$

Substituting the given values, we get

$$A_2 = -\frac{(1.5-1)15^0}{(1.75-1)} = -10^0$$

-ve sign shows that two prisms must be joined in opposition.

10 (d) Here, υ= +15 cm, u = + (15-5) = +10 cm

According to lens formula

$$\frac{1}{\upsilon} - \frac{1}{u} = \frac{1}{f} \qquad \Rightarrow \qquad \frac{1}{15} - \frac{1}{10} = \frac{1}{f}$$

$\Rightarrow$ f = -30 cm

11 (c): The condition for total internal reflection,

sin i > sin C

Where,

i = angle of incidence

C = critical angle

But, $\sin C = \frac{1}{\mu}$

$\therefore \sin i = \frac{1}{\mu}$ Or $\mu > \frac{1}{\sin i}$

$\mu > \frac{1}{\sin 45^0}$ [Since i = 45^0]

$\mu > \sqrt{2} \Rightarrow \mu > 1.414$

Hence, Option (c) is correct.

12 (c) Focal length of the lens remains same.

Intensity of image formed by lens is proportional to area exposed to incident light from object.

I.e. Intensity $\propto$ area

Or $\frac{I_2}{I_1} = \frac{A_2}{A_1}$

Initial area, $A_1 = \pi\left(\frac{d}{2}\right)^2 = \frac{\pi d^2}{4}$

After blocking, exposed area,

$$A_2 = \frac{\pi d^2}{4} - \frac{\pi(d/2)^2}{4}$$

$$= \frac{\pi d^2}{4} - \frac{\pi d^2}{16} = \frac{3\pi d^2}{16}$$

$$\therefore \frac{I_2}{I_1} = \frac{A_2}{A_1} = \frac{\frac{3\pi d^2}{16}}{\frac{\pi d^2}{4}} = \frac{3}{4}$$

Or $I_2 = \frac{3}{4} I_1 = \frac{3}{4} I \qquad (\because I_1 = I)$

Hence, focal length of a lens = f, intensity of the image = $\frac{3I}{4}$

13(c) Refractive index for medium M_1 is

$$\mu_1 = \frac{c}{v_1} = \frac{3\times10^8}{1.5\times10^8} = 2$$

Refractive index for medium M_2 is

$\sin i \geq \sin c$

Where I = angle of incidence

C = critical angle

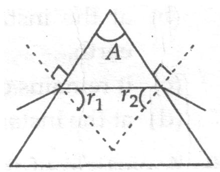
But $\sin C = \frac{\mu_2}{\mu_1}$

$$\sin i \geq \frac{\mu_2}{\mu_1} \geq \frac{3/2}{2} \Rightarrow i \geq \sin^{-1}\left(\frac{3}{4}\right)$$

14. (b) Angle of prism, $A = r_1 + r_2$

For minimum deviation

$r_1 = r_2 = r \quad \therefore A = 2r$



Given, $A = 60^0$

Hence, $r = \frac{A}{2} = \frac{60^0}{2} = 30^0$

AIIMS Previous Examination Questions

1. **Assertion: When a white light is passed through a lens, violet light is more refracted than red light.**

   Reason: Focal length for red light is greater than violet.

2. **Assertion: Microscope magnifies the image.**

   Reason: Angular magnification for image is more than object in microscope.

3. **Assertion: Magnification of a convex mirror is always positive, but that of a concave mirror may be either positive or negative.**

   Reason: It depends on the sign convention chosen.

4. **In a convex lens of focal length F, the minimum distance between an object and its real image must be**

   a) 3F b) 4F c) $\frac{3}{2}F$ d) 2F

5. **In Young's double slit experiment, fringe order is represented by m, and then fringe width is**

   a) Independent of m b) Directly proportional to m

   c) Directly proportional to (2m+1) d) Inversely proportional to (2m+1)

6. **Assertion: A thick lens shows more chromatic aberration.**

   Reason: Thick lens behave as many thin lenses.

7. **Assertion: The focal length of objective lens in telescope is much more than that of eye piece.**

Reason: Telescope has high resolving power due to large focal length.

Key

1. a	**2. a**	**3.b**	**4.b**	**5.a**	**6.c**	**7.b**

Solutions

1.

Sol: (a)

When white light is passes through a lens, violet light is more refracted than red light because wavelength of violet is less than red light and therefore focal length for red light is greater than violet.

2.

Sol: (a)

Microscope is an optical instrument which forms a magnified image of a small nearby object and thus, increases the visual angle subtended by the image at the eye so that the object is seen to be bigger and distinct. Therefore angular magnification for image is more than object.

3.

Sol: (b)

The sign of magnification depend on the sign convention chosen. According to the new Cartesian sign conventions, magnification for a convex mirror is positive because image formed by a convex mirror is always virtual and erect. A concave mirror can form virtual or erect images and also real, inverted images. In the latter case, its magnification becomes negative. The reason though correct does not explain the assertion properly.

4.

Sol: (b)

Let L is the distance between a real object and its real image formed by a convex lens, then as

L = $\left(|u|+|\upsilon|\right)$

$= \left(\sqrt{u}-\sqrt{\upsilon}\right)^2 + 2\sqrt{u\upsilon}$

L will be minimum when

$\left(\sqrt{u}-\sqrt{\upsilon}\right)^2 = 0$

i.e., u = υ

Putting, u = - u and υ = + u in lens

Formula

$$\frac{1}{\upsilon}-\frac{1}{u}=\frac{1}{F}$$

$$\frac{1}{u}-\frac{1}{-u}=\frac{1}{F}$$

$\therefore (L)_{min} = 2\sqrt{2F \times 2F} = 4F$ (Using (i))

5.

Sol: (a)

The fringe width is given by

$$\beta = \frac{\lambda D}{d}$$

Here D is the separation between screen and slits and d is the separation between slits

6.

Sol: (c)

Lenses have different refractive index for different wavelengths of light. The refractive index decreases with increasing wavelength. So red light will bend least and violet the most. This will result is slight dispersion which will be seen as chromatic aberration.

7.

Sol: (b)

In telescope to have a large magnifying power, focal length of objective lens is kept large. To increase the magnifying power and resolving power, aperture of the objective lens is made large.