DAY THIRTY

Unit Test 6

(Optics)

1 Minimum light intensity that can be perceived by normal human eye is about 10^{-10} W m^{-2}. What is the minimum number of photons of wavelength 660 nm that must enter the pupil in one second, for one to see the object? Area of cross-section of the pupil is 10^{-4} m^2.

(a) 3.3×10^2 (b) 3.3×10^3 (c) 3.3×10^4 (d) 3.3×10^5

2 A beam of light converges to a point P. A lens is placed in path of light 1.2 cm from P. If focal length of lens is +20 cm, then image distance from lens is

(a) 4.8 cm (b) 20 cm (c) 7.5 cm (d) 5.2 cm

3 A ray of light incident at an angle θ on a refracting face of a prism emerges from the other face normally. If the angle of the prism is 5° and the prism is made of a material of refractive index 1.5, the angle of incidence is

(a) $\sin^{-1}(0.13)$ (b) $\sin^{-1}(0.52)$ (c) $\sin^{-1}(0.17)$ (d) $\sin^{-1}(0.86)$

4 Two coherent point sources S_1 and S_2 vibrating in phase emit light of wavelength λ. The separation between the sources is 2λ. The smallest distance from S_2 on a line passing through S_2 and perpendicular to S_1S_2, where a minimum of intensity occurs is

(a) $\frac{7\lambda}{12}$ (b) $\frac{15\lambda}{4}$ (c) $\frac{\lambda}{2}$ (d) $\frac{3\lambda}{4}$

5 A thin glass prism $\mu = 1.5$ is immersed in water $\mu = 1.3$. If the angle of deviation in air for particular ray be D, then that in water will be

(a) 0.2 D (b) 0.3 D (c) 0.5 D (d) 0.6 D

6 The refractive index of the material of equilateral prism is $\sqrt{3}$. The angle of minimum deviation for the prism is

(a) 30° (b) 41° (c) 49° (d) 60°

7 A thin convergent glass lens $\mu = 1.5$ has a power of + 5.0 D. When this lens is immersed in a liquid of refractive index μ_l, it acts as a diverging lens of focal length 100 cm. The value of μ_l should be

(a) 3/2 (b) 4/3 (c) 5/3 (d) 2

8 A thin convex lens of crown glass having refractive index 1.5 has power 1 D. What will be the power of similar convex lens of refractive index 1.6 ?

(a) 0.6 D (b) 0.8 D (c) 1.2 D (d) 1.6 D

9 A short pulse of white light is incident from air to a glass slab at normal incidence. After travelling through the slab, the first colour to emerge is

(a) blue (b) green (c) violet (d) red

10 An object approaches a converging lens from the left of the lens with a uniform speed 5 m/s and stops at the focus. The image

(a) moves away from the lens with uniform speed 5 m/s
(b) moves away from the lens with uniform acceleration
(c) moves away from the lens with a non-uniform acceleration
(d) moves towards the lens with a non-uniform acceleration

11 A passenger in an aeroplane shall

(a) never see a rainbow
(b) may see a primary and a secondary rainbow as concentric circles
(c) may see a primary and a secondary rainbow as concentric arcs
(d) shall never see a secondary rainbow

12 A narrow slit of width 1 mm is illuminated by monochromatic light $\lambda = 600$ nm. The distance between first minima on either side of center line of a screen placed 2 m away is

(a) 1.2 cm (b) 1.2 mm (c) 2.4 mm (d) 2.4 cm

13 A myopic person having far point 80 cm uses spectacles of power –1.0 D. How far can he see clearly?

(a) 1 m (b) 2 m
(c) 4 m (d) More than 4 m

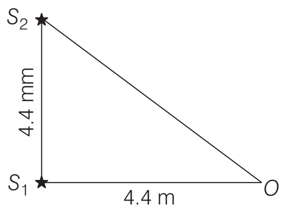
14 The radius of curvature of the curved surface of a plano-convex lens is 20 cm. If the refractive index of the material of the lens be 1.5, it will

(a) act as a convex lens only for the objects that lie on its curved side
(b) act as a concave lens for the objects that lie on its curved side
(c) act as a convex lens irrespective of the side on which the object lies
(d) act as a concave lens irrespective of the side on which the object lies

15 Monochromatic light of wavelength 800 nm is used in double slit experiment. One of the slit is covered with a transparent slab of thickness 2.4×10^{-5} m. The refractive index of the material of slab is 1.4. What is the number of fringes that will shift due to introduction of the sheet?

(a) 14 (b) 12 (c) 16 (d) 10

16 Two coherent sources are 4.4 mm apart and 4.4 m from the screen as shown in the figure. If the sources emit light of wavelength 440 nm which produce an interference pattern on the screen. The pattern of the interference at point O is



(a) constructive only
(b) destructive only
(c) cannot be predicted
(d) may be constructive or destructive

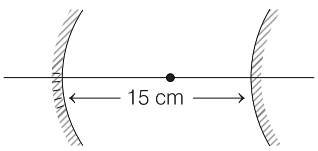
17 A lens behaves as a converging lens in air and a diverging lens in water. The refractive index of the material of the lens is

(a) equal to unity (b) equal to 1.33
(c) between unity and 1.33 (d) greater than 1.33

18 Angular width of central maximum in the Fraunhoffer's diffraction pattern is measured. Slit is illuminated by the light of wavelength 6000 Å. If slit is illuminated by light of another wavelength, angular width decreases by 30%. Wavelength of light used is

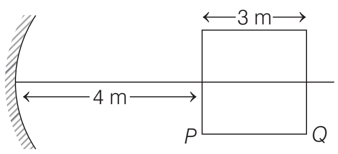
(a) 3500 Å (b) 4200 Å (c) 4700 Å (d) 6000 Å

19 A convex mirror and a concave mirror of radius 10 m each are placed 15 m apart facing each other. An object is placed mid-way between them. If the reflection first take place in the concave mirror and then in another mirror, the position of the final image is



(a) at infinity
(b) at the mid-point of distance between two mirrors
(c) on the pole of concave mirror
(d) on the pole of convex mirror

20 A cube of side 3 m is placed in front of a concave mirror of focal length 2 m with its face P at a distance 4 m and face Q at a distance 7 m from the mirror. What is distance between the images of face P and Q?



(a) 1.2 m (b) 2.4 m (c) 2.1 m (d) 2.2 m

21 A diminished image of an object is to be obtained on a screen 1 m from it. This can be achieved by approximately placing.

(a) a concave mirror of suitable focal length
(b) a convex mirror of suitable focal length
(c) a concave lens of suitable focal length
(d) a convex lens of focal length less than 0.25 m

22 A convex lens and a concave lens are placed in contact. The ratio of the magnitude of the power of the convex lens to that of the concave lens is 4 : 3. If the focal length of the convex lens is 12 cm, the focal length of the combination will be

(a) 16 cm (b) 24 cm (c) 32 cm (d) 48 cm

23 The radius of curvature of a thin plano-convex lens is 10 cm and the refractive index of its glass is 1.5. If the plane surface is silvered, then it will behave like a

(a) concave mirror of focal length 10 cm
(b) concave mirror of focal length 20 cm
(c) convex mirror of focal length 10 cm
(d) convex mirror of focal length 20 cm

24 When the plane surface of a plano-convex lens of refractive index 1.5 is silvered, it behaves like a concave mirror of focal length 30 cm. When its convex surface is silvered, it will behave like a concave mirror of focal length

(a) 10 cm (b) 20 cm (c) 30 cm (d) 45 cm

25 Two stars are situated at a distance of 8 light years from the earth. Their images are just resolved by a telescope of diameter 0.25 m. If the wavelength of light from stars is 5000 Å, then the distance between the stars is around

(a) 3×10^{10} m (b) 3.35×10^{11} m
(c) 1.95×10^{11} m (d) 4.32×10^{10} m

26 The refractive index of air is 1.0003. The thickness of air column which will have one more wavelength of yellow light ($\lambda = 6000$ Å), then in the same thickness in vacuum is

(a) 2 mm (b) 2 cm (c) 2 m (d) 2 km

27 A thin symmetric convex lens of refractive index 1.5 and radius of curvature 0.3 m is immersed in water of refractive index 4/3. Its focal length in water is

(a) 0.15 m (b) 0.30 m (c) 0.60 m (d) 1.20 m

28 A parallel beam of sodium light of wavelength 6000 Å is incident on a thin glass plate of $\mu = 1.5$, such that the angle of incidence in the plate is 60°. The smallest thickness of the plate which will make it appear dark by reflected light is

(a) 1260 Å (b) 2440 Å (c) 3260 Å (d) 4000 Å

29 Two polaroids are oriented with their principal planes making an angle of 60°. The percentage of incident unpolarised light which passes through the system is

(a) 50% (b) 100% (c) 12.5% (d) 37.5%

30 In the visible region of the spectrum the rotation of the plane of polarisation is given by $\theta = a + \frac{b}{\lambda^2}$.

The optical rotation produced by a particular material is found to be 30° per mm at $\lambda = 5000$ Å and 50° per mm at $\lambda = 4000$ Å. The value of constant a will be

(a) $+\frac{50^\circ}{9}$ per mm (b) $-\frac{50^\circ}{9}$ per mm
(c) $+\frac{9^\circ}{50}$ per mm (d) $-\frac{9^\circ}{50}$ per mm

31 The refracting angle of a prism is A and the refractive index of the prism is $\cot(A/2)$. The angle of minimum deviation is

(a) $180° - 3A$ (b) $180° + 2A$ (c) $90° - A$ (d) $180° - 2A$

32 Cross-section of a glass prism is an isosceles triangle. One of refracting faces is silvered. A ray of light falls normally on the other refracting face. After being reflected twice, it emerges through the base of the prism perpendicular to it. The angles of prism are

(a) 54°, 54°, 72° (b) 72°, 72°, 36°
(c) 45°, 45°, 90° (d) 57°, 57°, 76°

33 A spherical surface of radius of curvature R, separates air and glass ($n_{air} = 1.0$, $n_{glass} = 1.5$). The centre of curvature is in glass. A point object P placed in air is found to have a real image in the glass. The line PQ cuts the surface at a point O such that $PO = OQ$.

Distance PQ is

(a) $5R$ (b) $3R$ (c) $2R$ (d) R

34 Polarising angle for water is 53°4'. If light is incident at this angle on the surface of water and reflected, the angle of refraction is

(a) 53° 4′ (b) 126°56′
(c) 36°56′ (d) 30° 4′

35 The distance between the first and the sixth minima in the diffraction pattern of a single slit is 0.5 mm. The screen is 0.5 m away from the slit. If the wavelength of light used is 5000 Å, then the slit width will be

(a) 5 mm (b) 2.5 mm
(c) 1.25 mm (d) 1.0 mm

Direction (Q. Nos. 36-40) *Each of these questions contains two statements : Statement* I *and Statement* II. *Each of these questions also has four alternative choices, only one of which is the correct answer. You have to select one of the codes* (a), (b), (c) *and* (d) *given below*

(a) Statement I is true, Statement II is true; Statement II is the correct explanation for Statement I
(b) Statement I is true, Statement II is true; Statement II is not the correct explanation for Statement I
(c) Statement I is true; Statement II is false
(d) Statement I is false; Statement II is true

36 **Statement I** Angle of deviation depends on the angle of prism.

Statement II For thin prism $\delta = (\mu - 1)A$.

where, δ = angle of deviation, μ = refractive index, A = angle of prism.

37 **Statement I** Glass is transparent but its powder seems opaque. When water is poured over it, it becomes transparent.

Statement II Light gets refracted through water.

38 **Statement I** If convex lens is kept in water its convergent power decreases.

Statement II Focal length of convex lens in water increases.

39 **Statement I** Danger signals are made of red colours.

Statement II Velocity of red light is maximum and thus, more visibility in dark.

40 **Statement I** The clouds in sky generally appear to be whitish.

Statement II Diffraction due to clouds is efficient in equal measure for all wavelengths.

ANSWERS

1. (c)	**2.** (c)	**3.** (a)	**4.** (a)	**5.** (b)	**6.** (d)	**7.** (c)	**8.** (c)	**9.** (d)	**10.** (c)
11. (b)	**12.** (c)	**13.** (c)	**14.** (c)	**15.** (b)	**16.** (a)	**17.** (c)	**18.** (b)	**19.** (d)	**20.** (a)
21. (d)	**22.** (d)	**23.** (a)	**24.** (a)	**25.** (c)	**26.** (a)	**27.** (d)	**28.** (b)	**29.** (c)	**30.** (b)
31. (d)	**32.** (b)	**33.** (a)	**34.** (c)	**35.** (b)	**36.** (a)	**37.** (a)	**38.** (a)	**39.** (c)	**40.** (c)

Hints and Explanations

1 $I = 10^{-10}\ \text{Wm}^{-2} = 10^{-10}\text{Js}^{-1}\text{m}^2$. Let the number of photons required per second be n.

Then, $\frac{nhv}{10^{-4}} = 10^{-10}$

Hence, $n = 10^{-10} \times 10^{-4}/hv$

$$= 10^{-14}\frac{\lambda}{hc}$$

$$= \frac{10^{-14} \times 660 \times 10^{-9}}{6.6 \times 10^{-34} \times 3 \times 10^{8}}$$

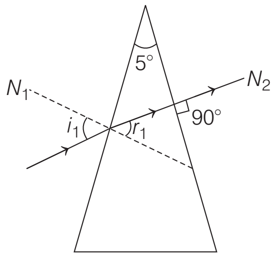
$$= 3.3 \times 10^4$$

2 $\frac{1}{v} = \frac{1}{f} + \frac{1}{u}$

Here, $f = +20$ and $u = +12$

$\therefore \quad v = 7.5\,\text{cm}$

3 Here, $A = 5°$, $i_1 = ?$



As the ray emerges from the other face of prism normally,

$i_2 = 0°$

$\therefore \quad r_2 = 0°$,

As $\quad r_1 + r_2 = A$

$r_1 = A - r_2 = 5 - 0 = 5°$

From $\mu = \frac{\sin i_1}{\sin r_1}$,

$\sin i_1 = \mu \sin r_1$

$\sin i_1 = 1.5 \times \sin 5°$

$= 1.5 \times 0.087$

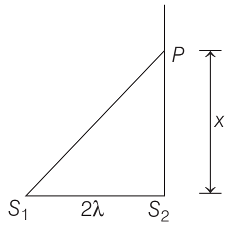
$\sin i_1 = 0.1305$

$i_1 = \sin^{-1}(0.1305)$

4 Path difference at S_2 is 2λ. Therefore, for minimum intensity at P.

$$S_1P - S_2P = \frac{3\lambda}{2} \neq \frac{\lambda}{2} \quad \ldots\text{(i)}$$

or $\sqrt{4\lambda^2 + x^2} - x = \frac{3\lambda}{2}$



Solving this equation, we get

$$x = \frac{7\lambda}{12}$$

5 $\delta \simeq (\mu - 1)A$

For air, $\quad D = (1.5 - 1)A$

For water, $\delta = ({}_g\mu_w - 1)A = \left(\frac{1.5}{1.3} - 1\right)A$

Hence, $\quad \delta = \frac{0.2}{1.3} \times \frac{D}{0.5} \cong 0.3D$

6 $$\mu = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin\left(\frac{A}{2}\right)}$$

$\Rightarrow \sqrt{3} = \frac{\sin\left(\frac{A + \delta_m}{2}\right)}{\sin 30°}$,

because $\quad A = 60°$

or $\sin\frac{A + \delta_m}{2} = \frac{\sqrt{3}}{2} = \sin 60°$

or $\quad A + \delta_m = 2 \times 60 = 120$

This gives $\delta_m = 60°$.

where, δ_m is minimum deviation.

7 When the lens is in air, we have

$$P_a = \frac{1}{f_a} = \frac{\mu_g - \mu_a}{\mu_a}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

When the lens is in liquid, we have

$$P_l = \frac{1}{f_l} = \frac{\mu_g - \mu_l}{\mu_l}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$$

Here, $\quad P_a = 5, P_l = -1, \mu_a = 1, \mu_g = 1.5$

On solving, we get

$$\mu_l = \frac{5}{3}$$

8 $\quad P = (\mu - 1)\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

Hence, $\frac{P_2}{P_1} = \left(\frac{\mu_2 - 1}{\mu_1 - 1}\right)$ i.e. $\frac{P_2}{1} = \frac{1.6 - 1}{1.5 - 1}$

Hence, $\quad P_2 = 1.2\ \text{D}$

9 In air, all the colours of light travel with the same velocity, but in glass, velocities of different colours are different. Velocity of red colour is largest and velocity of violet colour is smallest. Therefore, after travelling through the glass slab, red colour will emerge first.

10 When an object approaches a convergent lens from the left of the lens with a uniform speed of 5 m/s, the image moves away from the lens with a non-uniform acceleration. For example, $f = 20$ m and $u = -50$ m; -45 m, -40 m and -35 m; we get $v = 33.3$ m; 36 m; 40 m and 46.7 m. Clearly, image moves away from the lens with a non-uniform acceleration. Option (c) is correct.

11 In an aeroplane, a passenger may observe a primary and a secondary rainbow as concentric circles.

12 For first dark fringe on either side,

$$d\sin\theta = \lambda$$

and $\quad \sin\theta = \frac{y}{D}$

So, $\quad \frac{dy}{D} = \lambda$ or $y = \frac{\lambda D}{d}$

Distance between two minima $= 2y$

$$= \frac{2 \times 600 \times 10^{-6} \times 2 \times 10^3}{1.0}\ \text{mm}$$

$$= 2.4\ \text{mm}$$

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

Here, $\quad v = -80$ cm, $f = -100$ cm

Hence, $\frac{1}{-80} - \frac{1}{u} = -\frac{1}{100}$

or $-\frac{1}{u} = -\frac{1}{100} + \frac{1}{80} = \frac{-80 + 100}{80 \times 100}$

This gives $u = -400$ cm $= -4$ m

14 Here, $\mu = 1.5$

If object lies on plane side;

$$R_1 = \infty, R_2 = -20\text{ cm}$$

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

$$= (1.5 - 1)\left(\frac{1}{\infty} + \frac{1}{20}\right) = \frac{1}{40}$$

$$f = +40\text{ cm.}$$

The lens behaves as convex.

If object lies on its curved side,

$$R_1 = 20\text{ cm}, R_2 = \infty,$$

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

$$= (1.5 - 1)\left(\frac{1}{20} - \frac{1}{\infty}\right) = \frac{1}{40}$$

$$f' = 40\text{ cm}$$

The lens behaves as convex.

15 The total fringe shift is $H = \frac{\beta}{\lambda}(\mu - 1)t$

The number of fringes that will shift

$$= \frac{\text{total fringe shift}}{\text{fringe width}}$$

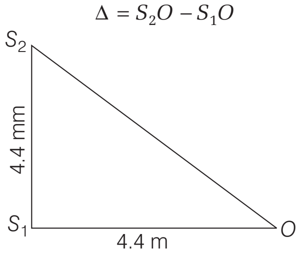
or $$n = \frac{\frac{\beta}{\lambda}(\mu - 1)t}{\beta} = \frac{(\mu - 1)t}{\lambda}$$

or $$n = \frac{(1.4 - 1) \times 2.4 \times 10^{-5}}{800 \times 10^{-9}}$$

or $$n = \frac{0.4 \times 2.4 \times 10^{-5}}{8 \times 10^{-7}} \text{ or } n = 12$$

16 The path difference at point of observation is given by

$$\Delta = S_2O - S_1O$$



From the figure,

$$S_2O = [(4.4)^2 + (4.4 \times 10^{-3})^2]^{1/2}$$

or $S_2O = 4.4[1 + (10^{-3})^2]^{1/2}$

or $S_2O = 4.4\left[1 + \frac{1}{2}(10^{-3})^2\right]$

Therefore, $\Delta = 4.4\left[1 + \frac{1}{2}(10^{-3})^2 - 1\right]$

$$= \frac{4.4 \times 10^{-6}}{2} = 2.2 \times 10^{-6}\text{ m}$$

Interference will be constructive, if path difference is an integral multiple of wavelength.

$$n = \frac{\Delta}{\lambda} = \frac{2.2 \times 10^{-6}}{440 \times 10^{-9}} = 5$$

Hence, pattern of interference at point O is constructive.

17 The focal length f of the lens in air is given by

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

where, μ_g is the refractive index of the lens. If μ_w is the refractive index of water, the focal length in water (f') is given by

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

Since, the lens placed in air is convergent, f is positive. Therefore, $\mu_g > 1$. For the lens to be divergent when placed in water, f' must be negative, i.e. $\mu_g < \mu_w$. Now, $\mu_w = 1.33$. Hence, μ_g must lies between 1 and 1.33.

18 The condition for minima is given by

$$d\sin\theta = n\lambda$$

For $n = 1$, we have

$$d\sin\theta = \lambda$$

If angle is small, then $\sin\theta = \theta \Rightarrow d\theta = \lambda$

Half angular width $\theta = \frac{\lambda}{d}$

Full angular width, $2\theta = 2\frac{\lambda}{d}$

Also, $\omega' = \frac{2\lambda'}{d}$

$$\therefore \quad \frac{\lambda'}{\lambda} = \frac{\omega'}{\omega}$$

or $$\lambda' = \lambda\frac{\omega'}{\omega} = 6000 \times 0.7 = 4200\text{ Å}$$

19 For reflection from concave mirror

Applying, $\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$, we get

$$\frac{1}{-5} = \frac{1}{v} - \frac{1}{7.5}$$

or $$\frac{1}{v} = -\frac{1}{5} + \frac{1}{7.5} \text{ or } v = -15\text{ m}$$

The image is formed on the pole of the convex mirror, which will be the position of the object for convex mirror. Therefore,

$$u = 0 \text{ and } f = 5\text{ m}$$

Hence, $$\frac{1}{v} = \frac{1}{5} - \frac{1}{0} = \frac{1}{5} - \infty = \infty$$

or $$v = 0$$

Therefore, final image is formed on the pole of convex mirror.

20 For surface P, we have

$$\frac{1}{v_1} = \frac{1}{f} - \frac{1}{u}$$

$$= \frac{1}{2} - \frac{1}{4} = \frac{1}{4} \text{ or } v_1 = 4\text{ m}$$

For surface Q, we have

$$v_2 = \frac{1}{2} - \frac{1}{7} = \frac{5}{14}$$

or $$v_2 = \frac{14}{5} = 2.8\text{ m}$$

Therefore, $v_1 - v_2 = (4 - 2.8) = 1.2\text{ m}$

21 Convex mirror and concave lens do not form real image. For concave mirror $v > u$, so image will be enlarged, hence only convex lens can be used for the purpose.

22 Given, $f_1 = +12\text{ cm}$ and $\frac{|P_1|}{|P_2|} = \frac{4}{3}$

Since f_2 is negative, $\frac{f_2}{f_1} = -\frac{4}{3}$

Hence, $f_2 = -\frac{4}{3}f_1 = -\frac{4}{3} \times 12$

$$= -16\text{ cm}$$

The focal length F of the combination is given by

$$\frac{1}{F} = \frac{1}{f_1} + \frac{1}{f_2} = \frac{1}{12} + \frac{1}{-16} = \frac{1}{48}$$

$$F = 48\text{ cm}$$

23 When the plane surface of a plano-convex lens is silvered, it behaves like a concave mirror of focal length f given by

$$\frac{1}{f} = \frac{2(\mu - 1)}{R}$$

or $$f = \frac{R}{2(\mu - 1)} = \frac{10}{2(1.5 - 1)} = 10\text{ cm}$$

24 When the plane surface is silvered the focal length f_1 is given by

$$\frac{1}{f_1} = \frac{2(\mu - 1)}{R} \quad \text{... (i)}$$

But when the convex surface is silvered, the focal length f_2 is given by

$$\frac{1}{f_2} = \frac{2\mu}{R} \quad \text{... (ii)}$$

Dividing Eq. (i) by Eq. (ii), we have

$$\frac{f_1}{f_2} = \frac{\mu}{\mu - 1} = \frac{1.5}{1.5 - 1} = 3$$

or $$f_2 = \frac{f_1}{3} = \frac{30}{3} = 10\text{ cm}$$

25 Limit of resolution of the telescope

$$\alpha = \frac{1.22\lambda}{a} = \frac{d}{x}$$

or $$d = \frac{1.22\lambda\, x}{a}$$

$$= \frac{1.22 \times 5 \times 10^{-7} \times 8 \times 10^{16}}{0.25}$$

$$= 1.95 \times 10^{11}\text{ m}$$

26 Let d in cm be the thickness of air column = thickness of vacuum column (given). Number of waves of wavelength $\lambda = 6000$ Å $= 6 \times 10^{-5}$ cm in a thickness d cm in vacuum is

$$n_v = \frac{d}{\lambda}$$

Since, the refractive index of air $\mu = 1.0003$, the wavelength in air will be

$$\lambda_a = \frac{\lambda}{\mu}$$

Therefore, number of waves of wavelength λ_a in d cm of air is

$$n_a = \frac{d}{\lambda_a} = \frac{d\mu}{\lambda}$$

Given that, $n_a - 1 = n_v$

Hence, $\frac{d\mu}{\lambda} - 1 = \frac{d}{\lambda}$

$$d = \frac{\lambda}{\mu - 1} = \frac{6\times10^{-5}\text{cm}}{1.0003 - 1}$$

$$= 0.2 \text{ cm} = 2 \text{ mm}$$

27 $\frac{1}{f} = \frac{\mu_g - \mu_w}{\mu_w}\left[\frac{1}{R_1} - \frac{1}{R_2}\right]$

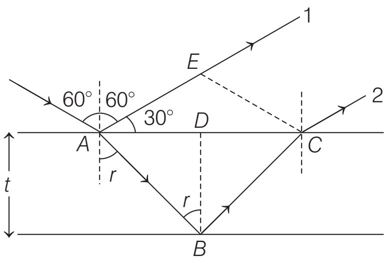
For a symmetric lens

$$R_2 = -R_1 = -0.3 \text{ m}$$

Therefore, $\frac{1}{f} = \frac{(1.5 - 4/3)}{4/3}\left[\frac{1}{0.3} + \frac{1}{0.3}\right]$

which gives $f = 1.20$ m

28



$$\sin r = \frac{\sin 60°}{\mu} = \frac{\sqrt{3}/2}{1.5}$$

$$\therefore \quad r = 30°$$

$$AB = t\sec r = 1.15t$$

$$AC = 2(AD) = 2(t \tan r) = 1.15t$$

$$AE = AC\cos 30° = 0.99t$$

Now, net path difference between 1 and 2,

$$\Delta X = \mu(2AB) - AE$$

$$= (1.5)(2.3t) - 0.99t = 2.45t$$

For minimum intensity,

$$\Delta X = \lambda$$

or $(2.45t) = 6000$

or $t = 2448 \text{ Å} \approx 2440 \text{ Å}$

29 Intensity of polarised light from first polariser $= \frac{100}{2} = 50$

From law of Malus intensity from second nicol

$$I = 50\cos^2 60°$$

$$= \frac{50}{4} = 12.5\%$$

30

$$\theta = a + \frac{b}{\lambda^2}$$

$$30 = a + \frac{b}{(5000)^2}$$

and $50 = a + \frac{b}{(4000)^2}$

Solving for a, we get

$$a = -\frac{50°}{9} \text{ per mm}$$

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

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

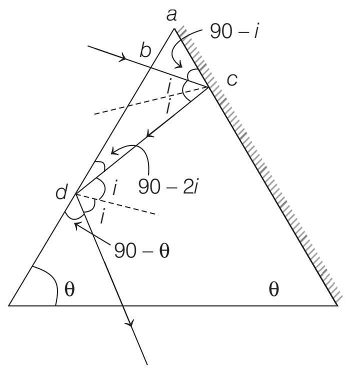
or $\sin\left(\frac{A+\delta_m}{2}\right) = \cos\left(\frac{A}{2}\right)$

$$= \sin\left(90° - \frac{A}{2}\right)$$

$$\therefore \quad \frac{A+\delta_m}{2} = 90° - \frac{A}{2}$$

or $\delta_m = 180° - 2A$

32



In Δabc,

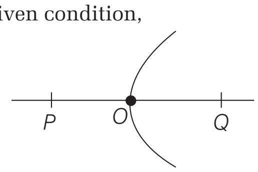
$$A + 90° + 90° - i = 180°$$

$$\Rightarrow \quad i = A$$

Also, angle $\theta = 2i = 2A$

This condition is satisfied by option (b) only.

33 For given condition,



$$\frac{\mu_1}{-u} + \frac{\mu_2}{v} = \frac{\mu_2 - \mu_1}{R}$$

$$\frac{1}{-(-x)} + \frac{1.5}{x} = \frac{1.5-1}{R}$$

$$\Rightarrow \quad x = 5R$$

34 $i_p + r = 90°$

or $r = 90° - i_p = 90° - 53°4' = 36°56'$

35 For the first minimum,

$$a\sin\theta_1 = \lambda \approx a\theta_1 = \frac{ad_1}{D}$$

For the sixth minimum,

$$a\sin\theta_6 = 6\lambda = a\theta_6 = \frac{ad_6}{D}$$

$$\therefore \quad (6\lambda - \lambda) = \frac{a}{D}(d_6 - d_1)$$

or $a = \frac{5D\lambda}{(d_6 - d_1)}$

$$= \frac{5\times 0.5\times 5\times 10^{-7}}{0.5\times 10^{-3}}$$

$$= 2.5\times 10^{-3} \text{ m}$$

$$= 2.5 \text{mm}$$

36 The relation between angle of deviation δ for a thin prism an angle of prism and refractive index of material of prism is given by $\delta = (\mu - 1)A$

37 We know very well that, glass is transparent. But when the glass is powdered, the irregular reflections occur from the surface of powdered glass and finally the light returns back into the same medium. Because of it the powdered glass looks opaque. When we pour water over the powdered glass, refraction of light takes place and it becomes transparent.

38 The focal length f_w of convex lens in water of refractive index μ_w is given by

$$\frac{1}{f_w} = \left(\frac{\mu_g - \mu_w}{\mu_w}\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \quad ...(i)$$

Here, μ_g is the refractive index of lens (glass).

The focal length of lens in air is given by

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

From Eqs. (i) and (ii), we conclude the focal length of lens in water (f_w) is greater than focal length of lens in air (f_a). Therefore, the focal length of lens in water get increased consequently power decreases.

39 Red colour consists of longest wavelength and it scatteres least. Therefore, signals of red colour are being seen from the long distances. Hence, the signals are made of red colour light.

40 The clouds consist of dust particles and water droplets. The scattering of sun light by the big dust particles and water drops is not in accordance with the Rayleigh law. But they scatter the light of all the colours by the same amount. Hence, the clouds are seen generally white.