Chapter

10 WAVE OPTICS

1. Huygens' principle of secondary wavelets may be used to

(a) Find the velocity of light in vacuum

(b) explain the particle's behavior of light

(c) find the new position of a wavefront

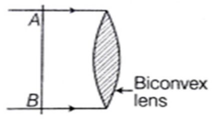
(d) explain photoelectric effect.

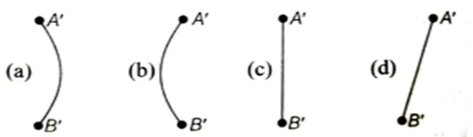
2. In Huygen' wave theory, the locus of all points in the same state of vibration is called

(a) a half period zone (b) oscillator

(c) a wave fronts (d) a ray

3. If *AB* is incident wave front. Then, refracted wave front is





4. Two sources S_1 and S_2 emitting light of wavelength 600nm are placed at a distance $1.0 \times 10^{-2}\ cm$ apart. A detector can be moved on the line $S_1 P$ which is perpendicular to $S_1 S_2$. The position of the farthest minimum detected is approximately

(a) 1.5 m (b) 1.0 m

(c) 1.07 m (d) 1.03 m

5. The phase difference between the two light waves reaching at the point $P\ is\ 100\pi$ .Their path difference is equal to

(a) 10 λ (b) 25 λ (c) 50 λ (d) 100 λ

6. In the phenomenon of interference, energy is

(a) destroyed at destructive interference

(b) created at constructive interference

(c) conserved but it is redistributed

(d) same at all points

7. The ratio of maximum and minimum intensities of two sources is 4 : 1 . The ratio of their amplitudes is

(a) 1 : 81 (b) 3 : 1

(c) 1 : 9 (d) 1 : 16

8. When two coherent monochromatic beams of intensity I and $9I$ interference, the possible maximum and minimum intensities of the resulting beam are

(a) $9I$ and I (b) $9I$ and $4\,I$

(c) $16\,I$ and $4\,I$ (d) $16\,I$ and I

9. Two slits in Young's double slit experiments have width in ratio 1 : 25. The ratio of intensity at the Maxima and minima in the interference pattern $\frac{I_{max}}{I_{min}}$ is

(a) $\frac{9}{4}$ (b) $\frac{121}{49}$ (c) $\frac{49}{121}$ (d) $\frac{4}{9}$

10. Light from two coherent sources of the same amplitude A and wavelength λ interference. The maximum intensity recorded is I_0. If the sources were incoherent, the intensity at the same point will be

(a) $4I_0$ (b) $2I_0$ (c) I_0 (d) $I_0/2$

11. In an experiment with two coherent sources, the amplitude of the intensity variation is found to be 5% of the average intensity. The relative intensities of the light waves of interfering sources will be

(a) 1600 : 1 (b) 900 : 1

(c) 40 : 1 (d) 400: 1

12. White light may be considered to be mixture of wavelength ranging between 3000Å and

7800 Å. An oil film of thickness 10000 Å is examined normally by the reflected light . If $\mu = 1.4$, then the film appears bright for

(a) 4308 Å, 5091 Å, 6222 Å

(b) 4000 Å, 5091 Å, 5600 Å

(c) 4667 Å, 6222 Å, 7000 Å

(d) 4000 Å, 4667 Å, 5600 Å, 7000 Å

13. In Young's double slit experiment, a glass plate is placed before a slit which absorbs half the intensity of light. Under this case

(a) the brightness of fringes decreases

(b) the fringe width decreases

(c) no fringes will be observed

(d) the bright fringes become fainter and the dark fringes have finite light intensity

14. A parallel beam of sodium light of wavelength 6000 Å is incident on a thin glass plate of refractive index 1.5 such that the angle of refraction in the plate is 60°. The smallest thickness of the plate which will make it dark by reflection.

(a) 4000 Å (b) 4200 Å

(c) 1390 Å (d) 2220 Å

15. In Young's double slit experiment two disturbance arriving P have phase difference of π /2. The intensity of this point expressed as a fraction of maximum intensity I_0 is

(a) $\frac{3}{2}I_0$ (b) $\frac{1}{2}I_0$ (c) $\frac{4}{3}I_0$ (d) $\frac{3}{4}I_0$

16 Two monochromatic light wave of same amplitudes of $2\,A$ interferring at a point have a phase difference of 60°. The intensity at that point will be proportional to

(a) $5\,A^2$ (b) $12A^2$ (c) $7\,A^2$ (d) $19\,A^2$

17. The shape of the fringe obtained on the screen in case of Young's slit experiment is

(a) a straight line (b) a parabola

(b) a hyperbola (d) a circle

18. In young's double slit experiment, distance between slit in kept 1 mm and a screen is kept 1m apart from slits. If wavelength of light used is 500 nm , then fringe spacing is

(a) 0.5 mm (b) 0.5 cm

(c) 0.25 mm (d) 0.25 cm

19. The maximum intensity of fringes in Young's double slit experiment is I. If one of the slit is closed, then the intensity at that place becomes I_0. Which of the following relations is correct?

(a) $I = I_0$

(b) $I = 2I_0$

(c) $I = 4I_0$

(d) There is no relation between I and I_0

20. If young's double slit experiment, is performed in water, the fringe width recorded is ω_2. If it is performed in air, the fringe width recorded is ω_1.

Then, ω_1 / ω_2 is ($\mu_{water} = 4/3$)

(a) 3/2 (b) 3/4

(c) 4/3 (d) Data insufficient

21. The young's double slit experiment is performed with blue and with green light of wavelengths 4360 Å and 5460Å, respectively. If x is the distance of 4th maximum from the central one, then

(a) $x(blue) = x(green)$

(b) $x(blue) > x(green)$

(c) $x(blue) < x(green)$

(d) $\frac{x(blue)}{x(green)} = \frac{5460}{4360}$

22. In Young's double slit experiment, the slits are 2mm apart and are illuminated by photons of two wavelengths $\lambda_1 = 12000$ Å and $\lambda_2 = 10000$ Å. At what minimum distance from the commom central bright fringe on the screen 2 m from the slit will a bright fringe from one interference pattern coincide with a bright fringe from the other?

(a) 8mm (b) 6mm (c) 4mm (d) 3mm

23. In Young's double slit experiment, the distance between two slit is 0.1 mm and these are illuminated with light of wavelength 5460 Å . the angular positions of first dark fringe on the screen distant 20 cm from slit will be

(a) 0.8 ° (a) 0.6 ° (c) 0.4 ° (d) 0.16. °

24. In Young's double slit experiment, let S_1 *and* S_2 be the two slits and C be the centre of the $< S_1CS_2 = \theta$ and λ is the wavelength, then fringe width will be

(a) $\frac{\lambda}{\theta}$ (b) $\lambda\theta$ (c) $\frac{2\lambda}{\theta}$ (d) $\frac{\lambda}{2\theta}$

25. Young's double slit experiment is made in a liquid. The 10th bright fringe in liquid lies, where 6th dark fringes lies in vacuum. The refractive index of the liquid is approximately

(a) 1.8 (b) 1.54 (c) 1.67 (d) 1.2

26. In the Young's double slit experiment using a monochromatic light of wavelength λ the path difference (in terms of an integer n) corresponding to any point having half the peak intensity is

(a) $(2n+1)\frac{\lambda}{2}$ (b) $(2n+1)\frac{\lambda}{4}$

(c) $(2n+1)\frac{\lambda}{8}$ (d) $(2n+1)\frac{\lambda}{16}$

27. In Young's double slit experiment, the slit width and the distance of slits from the screen both are double. The fringe width

(a) increases (b) decreases

(c) remain unchanged (d) None of these

28. In Young's double slit experiment using monochromatic light of wavelength λ, the path difference (in terms of an integer n) corresponding to any point having half the peak intensity is

(a) $(2n+1)\frac{\lambda}{2}$ (b) $\frac{(2n+1)\lambda}{4}$

(c) $(2n+1)\frac{\lambda}{8}$ (d) $\frac{(2n+1)\lambda}{16}$

29. In the Young's double-slit experiment, the intensity of light at a point on the screen (where the path difference is) is K.(λ being the wavelength of light used). The intensity at a point where the path difference is $\lambda/4$, will be

(a) K (b) K/4 (c) K/2 (d) zero

30. In a single slit diffraction of light of wavelength λ is used and slit of width e, the size of the central maxima on a screen at a distance b is

(a) $2b\lambda + e$ (b) $\frac{2b\lambda}{e}$

(c) $\frac{2b\lambda}{e} + e$ (d) $\frac{2b\lambda}{e} - e$

31. In single-slit diffraction pattern observed on a screen placed at D m distance from the slit of width $d\ m$, the ratio of the width of the central maximum to the width of other secondary maximum is

(a) 2 : 1 (b) 1 : 2 (c) 1 : 1 (d) 3 : 1

32. In a diffraction pattern due to a single slit of width a, the first minimum is observed at an angle 30° when light of wavelength 5000 Å is incident of the slit. The first secondary maximum is observed at an angle of

(a) $sin^{-1}\left(\frac{2}{3}\right)$ (b) $sin^{-1}\left(\frac{1}{2}\right)$

(c) $sin^{-1}\left(\frac{3}{4}\right)$ (d) $sin^{-1}\left(\frac{1}{4}\right)$

33. A parallel beam of fast moving electrons is incident normally on a narrow slit. A fluorescent screen is placed at a large distance from the slit. If the speed of the electrons is increased, then which of the following statements is correct?

(a) Diffraction pattern is not observed on the screen in the case of electrons

(b) The angular width of the central maximum of the diffraction pattern will increases

(c) The angular width of the central maximum will decreases

(d) The angular width of the central maximum will be unaffected

34. A single –slit of width d is illuminated by violet light of wavelength 400nm and the width of the central maxima is measured as y. When half of the slit width is covered and illuminated by

yellow light of wavelength 600nm, the width of the central diffraction pattern is

(a) the pattern vanishes and the width is zero

(b) y/3

(c) 3 y

(d) None of the above

35. A beam of light of $\lambda = 600$nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between first dark fringes on either side of the central bright fringe is

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

36. In a Young's double slit experiment, the screen is placed at a distance of 1.25m from the slits. When the apparatus is immersed in water. $(\mu\omega = 4/3)$, the angular width of a fringe is found to be 0.2°. When the experiment is performed in air with same set up, the angular width of the fringe is

(a) 0.4° (b) 0.28° (c) 0.35° (d) 0.15°

37. The angular resolution of the telescope is determined by the

(a) image produced by the the telescope

(b) objective of the telescope

(c) Both (a) and (b)

(d) Neither (a) nor (b)

38. What will be the ratio (D/f) in microscope, where D is the diameter of the aperture and f is the focal length of the objective lens?

(a) $tan\, \beta$ (b) $tan \frac{\beta}{2}$

(c) $2\, tan\beta$ (d) $tan \frac{\beta}{6}$

39. In a Fresnel biprism experiment, the two positions of lens separation between the slits as 25 cm and 16 cm respectively. The actual distance of separation

(a) 20 cm (b) 16 cm

(c) 18 cm (d) 20.5 cm

40. Which of the following is a diachronic crystal?

(a) Quartz (b) Tourmaline

(c) Mica (d) Selenite

41. In the propagation of light waves, the angle between the direction of vibration and plane of polarization is

(a) 0° (b) 90°

(c) 45° (d) 80°

42. An unpolarised beam of light of intensity I_0 falls on a polariod. The intensity of the emergent beam is

(a) $\frac{I_0}{2}$ (b) I_0 (c) $\frac{I_0}{4}$ (d) zero

43. An unpolarised beam I ntensity I_0 is incident on a pair of nicols making an angle of $60°$ with each. The intensity of light emerging the pair is

(a) I_0 (b) $I_0/2$

(c) $I_0/4$ (d) $I_0/8$

44. A beam of ordinary unpolarised light of intensity I_0 is passed through a polaroid A and then through another polariod B which is oriented so that its principal plane makes an angle of 45° relative to that of A. The intensity of the emergent light is

(a) I_0 (b) $I_0/2$

(c) $I_0/4$ (d) $I_0/8$

45. When unpolarised light beam is incident from air to glass$(\mu = 1.5)$ at the polarizing angle.

(a) reflected beam is polarizing angle

(b) reflected and refracted beams are partially polarized

(c) the reason for (a) is that almost all the light is reflected

(d) All of the above

46. At what angle should an unpolarised beam to incident on a crystal of $\mu = \sqrt{3}$, so that reflected beams is polarized?

(a) 45° (b) 60° (c) 90° (d) 0°

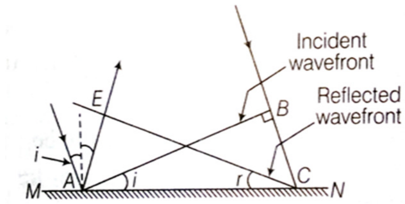
47. The critical angle of a certain medium is $sin^{-1}\left(\frac{4}{5}\right)$

The polarizing angle of medium is

(a) $tan^{-1}\left(\frac{5}{4}\right)$ (b) $sin^{-1}\left(\frac{4}{5}\right)$

(c) $sin\left(\frac{5}{4}\right)$ (d) $tan^{-1}\left(\frac{4}{3}\right)$

48. In case of reflection of a wave front from a reflecting surface,



I. Points A and E are in same phase

II. Points A and C are in same phase

III. Points B and A are in same phase

IV. Points C and E are in same phase

(a) I and II (b) II and III

(c) III and IV (d) I and IV

49. The 6563 Å H_α sign line emitted by hydrogen in a star is found to be red shifted by 15 Å. Estimate the speed with which the star is receding from the earth.

(a) $-5.04 \times 10^2 ms^{-1}$

(b) $-6.86 \times 10^5 ms^{-1}$

(c) $-5.84 \times 10^2 ms^{-1}$

(d) $-8.8 \times 10^3 ms^{-1}$

50 A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1m away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen. Find the width of the slit.

(a) 2mm (b) 1mm (c) 0.2 mm d) 0.1 mm

51. Consider a ray of light incident from air onto a slab of glass(refractive index n) of width d, at an angle θ. The phase difference between the ray reflected by the top surface of the glass and the bottom surface is

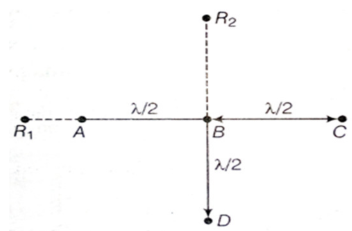
(a) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}sin^2\theta\right)^{1/2}+\pi$

(b) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}sin^2\theta\right)^{1/2}$

(c) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}sin^2\theta\right)^{1/2}+\frac{\pi}{2}$

(d) $\frac{4\pi d}{\lambda}\left(1-\frac{1}{n^2}sin^2\theta\right)^{1/2}+2\pi$

52. Four indentical monochromatic sources A, B, C, D as shown in the figure, produce waves of the same wavelength λ and are coherent. Two receiver R_1 and R_2 are at great but equal distances from B



Which of the two receivers picks up the larger signal?

(a) R_1 (b) R_2

(c) R_1 and R_2 (d) None of these

Hints and Explanations

1. (c)

Every point on a given wavefront act as a secondary source of light and emits secondary wavelets which travels in all directions with the speed of light in the medium. A surface touching all these secondary wavelets tangentially in the forward direction, gives new wavefront at that instant of time

2. (c)

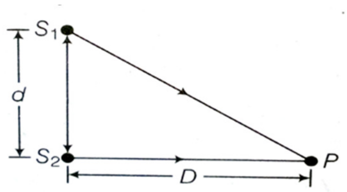
In Huygen's wave theory, the locus of all points in the same state of vibration is called a wave front.

3. (b)

4. (c)

The position of farthest minimum detection occurs when the path difference is least and odd multiple of $\frac{\lambda}{2}$, i.e.,

Condition for destructive interference and approaches zero as P moves to finity



$S_2P = D$

$S_1 P - S_2P = (2n+1)\frac{\lambda}{2}$ for destructive interference.

$(n = 0,1,2 \ldots.)$. For fathest distance

$S_1P - S_2P = \frac{\lambda}{2}$

$\Rightarrow \quad \sqrt{D^2 + d^2} - D = \frac{\lambda}{2}$

$\Rightarrow \quad D^2 + d^2 = \left(D + \frac{\lambda}{2}\right)^2$

$\Rightarrow \quad d^2 = D\lambda + \frac{\lambda^2}{4}$

$\Rightarrow \quad D = \frac{d^2}{\lambda} - \frac{\lambda}{4}$

$\Rightarrow \quad = \frac{(1.0\times10^{-4}\,m)^2}{(600\times10^{-9}m)} - 150\times10^{-9}\,m$

$= 107\,cm$

$\Rightarrow \quad D = 1.07\,m$

5. (c)

$\Delta\phi = 100\pi$

change in phase difference,

i.e., $\quad \Delta\phi = \frac{2\pi}{\lambda} \times \Delta x$

$\Delta x = path\ difference$

$\Rightarrow \quad \Delta x = \Delta\phi \times \frac{\lambda}{2\pi} = 100\pi \times \frac{\lambda}{2\pi} = 50\lambda$

6. (c)

7. (b)

$\frac{I_{max}}{I_{max}} = \frac{4}{1}$

$\frac{I_{max}}{I_{min}} = \left(\frac{r+1}{r-1}\right)^2 = \frac{4}{1}$

$\Rightarrow \quad \frac{r+1}{r-1} = \frac{2}{1} \quad \Rightarrow r+1 = 2r-2 \text{ or } r = 3$

$\therefore$ The ratio of amplitudes $\frac{A_1}{A_2} = r = 3$

8. (c)

$I_1 = I \text{ and } I_2 = 9I$

$\Rightarrow \quad \frac{I_1}{I_2} = \frac{I}{9I} = \frac{1}{9} \Rightarrow r = \frac{A_1}{A_2} = \frac{\sqrt{I_1}}{\sqrt{I_2}} = \sqrt{\frac{1}{9}} = \frac{1}{3}$

$\frac{I_{max}}{I_{min}} = \left(\frac{r+1}{r-1}\right)^2$ ......(i)

$= \left(\frac{\frac{1}{3}+1}{\frac{1}{3}-1}\right)^2 = \frac{16}{4} = 4$

9. (a)

Young's double slit experiment, having two slits of width are in the ratio of 1:25

ratio of intensity

$\frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{1}{25} \Rightarrow \frac{I_2}{I_1} = \frac{25}{1}$

$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{I_2} + \sqrt{I_1})^2}{(\sqrt{I_2} - \sqrt{I_1})^2} = \left(\frac{\sqrt{\frac{I_2}{I_1}}+1}{\sqrt{\frac{I_2}{I_1}}-1}\right)^2$

$\Rightarrow \quad \left[\frac{5+1}{5-1}\right]^2 = \left(\frac{6}{4}\right)^2 = \frac{36}{16} = \frac{9}{4}$

$\frac{I_{max}}{I_{min}} = \frac{9}{4}$

10. (d)

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2 = 4I_0'(if\ I_1 = I_2 = I_0')$

Here, $\quad 4I_0' = I_0$

$\Rightarrow \qquad I_0' = \frac{I_0}{4}$

For incorherent source, the interference has uniform intensity throughout given by

$$I = I_1 + I_2$$

or $\qquad I = 2I_0' = 2 \times \frac{I_0}{4} = \frac{I_0}{2}$

11. (a)

Average intensity be I_{av} .

The amplitude of intensity variation means

$I = I_{av} \pm 0.05\, I_{av}$

$\Rightarrow I_{max} = I_{av}$ (1 + 0.05) = 1.05 I_{av}

$\Rightarrow I_{min} = I_{av}$ (1 - 0.05) = 0.95 I_{av}

$\frac{I_{max}}{I_{min}} = \frac{1.05}{0.95} = \frac{105}{95}$

$\Rightarrow \left(\frac{r+1}{r-1}\right)^2 = \frac{105}{95}$

$\Rightarrow (r^2 + 1 + 2r)95 = 105(r^2 + 1 - 2r)$

$\Rightarrow 10r^2 + 10 - 200.2r = 0$

$\Rightarrow 10r^2 - 400r + 10 = 0$

$\Rightarrow r^2 - 4r + 1 = 0$

$\Rightarrow \quad r = \frac{40 \pm \sqrt{(40)^2 - 4 \times 1 \times 1}}{2}$

$r \approx \frac{40 + 40}{2} = 40$

$\therefore \frac{I_1}{I_2} = r^2 = (40)^2 = \frac{1600}{1}$

or $\quad I_1 : I_2 = 1600 : 1$

12. (a)

The film appears bright if the path difference is

$2\mu t = (2n-1)\frac{\lambda}{2}$, n = 1, 2, 3 ,.......

$\therefore \quad \lambda = \frac{4\,\mu t}{(2n-1)}$

$\lambda = \frac{4 \times 1.4 \times 10000 \times 10^{-10}}{(2n-1)} = \frac{56000}{(2n-1)}$Å

$\therefore \lambda$ = 56000 Å , 18666 Å , 11200 Å , 8000 Å , 6222 Å, 5091 Å , 4308 Å, 3733 Å

The wavelength which are not within specific range produce minima .

13. (d)

Intensity of bright band,

$I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$ ------- (i)

Intensity of bright band,

$I_{min} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$ ------- (ii)

Case I when there is no glass slab

$\Longrightarrow I_1 = I_2 = I_0$

Or $\quad I_{max} = 4\, I_0$ (complete brightnes)

Case II when glass slab is inserted ,

$\Longrightarrow I_1 < I_2$ or $I_1 = \frac{I_0}{2}$ and $I_2 = I_0$ (given)

Or $I_{max} < 4\, I_0$ [from eq. (i)

And $I_{min} > 0$ [from eq. (ii)

The bright band becomes less bright and dark band becomes less dark .

14. (a)

The condition for minimum thickness corresponding to a dark band in reflection

$2\,\mu \cos r = \lambda$

$\therefore \quad t = \frac{\lambda}{2\,\mu \cos r} = \frac{6000 \times 10^{-10}}{2 \times 1.5 \times \cos 60^o} = 4000$Å

15. (b)

The resultant intensity

$I = I_0 cos^2 \frac{\phi}{2}$

$I = I_0 cos^2 \left(\frac{\pi}{2 \times 2}\right) = I_0 cos^2 \frac{\pi}{4}$

$I = \frac{I_0}{2}$

16. (b)

$A_1 = 2A$, $A_2 = 2A$, $\phi = 60^o$

$R = \sqrt{A_2^1 + A_2^2 + 2A_1A_2 \cos\phi}$

$= \sqrt{(2A)^2 + (2A)^2 + 2 \times 2A \times 2A \times cos60^o}$

$= A\sqrt{12}$

As intensity $\propto (Amplitude)^2$

$I \propto 12\, A^2$

17. (c)

18. (a)

Fringe spacing

$\beta = \frac{D\lambda}{d} = \frac{1 \times 5 \times 10^{-7}}{1 \times 10^{-3}}\, m$ (1 nm = $10^{-9} m$)

$= 5 \times 10^{-4}$ m = 0.5 mm

19. (c)

Suppose slit width are equal , so they produces wave of equal intensity say I' .

Resultant intensity at any point $I_R = 4\, I' cos^2\phi$, where ϕ is the phase difference between the moves at the point of observation . For maximum intensity.

$\phi = 0$ $\Rightarrow I_{max} = 4\, I' = I$ ---------- (i)

when one slit is closed

$I' = I_0$ ------- (ii)

(i) and (ii) $4\, I_0 = I$

20. (c)

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

$\frac{\omega_1}{\omega_2} = \frac{\omega_{water}}{\mu_{air}} = \frac{4}{3}$

21. (c)

Position of nth maximum from central maxima

$= \frac{n\,\lambda\, D}{d} \Rightarrow x_n\, \alpha\, \lambda$

$x, (blue) < x\, (green\,) as \lambda_{blue} < \lambda_{green}$

22. (b)

λ_1 = 12000 Å and λ_2 = 10000 Å

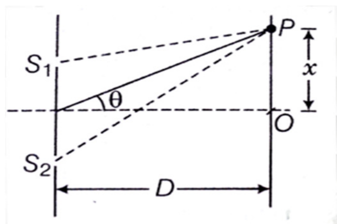
D = 2cm and d = 2mm = $2 \times 10^{-3} cm.$

$\frac{\lambda_1}{\lambda_2} = \frac{12000}{10000} = \frac{6}{5} = \frac{n_2}{n_1}$

$x = \frac{n_1\lambda_1\, D}{d} = \frac{5 \times 1200 \times 10^{-10} \times 2}{2 \times 10^{-3}}$

$= 5 \times 1.2 \times 10^4 \times 10^{-10} \times 10^3$ = 6 mm

23. (d)



Angular position of first dark fringe = $\tan\theta \approx \theta = \frac{x}{D}$

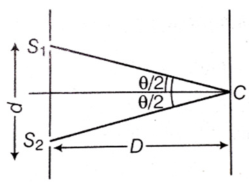
$\Rightarrow \theta = \frac{\lambda}{2\,d} = \frac{5460 \times 10^{-10}}{0.1 \times 10^{-3}} \left(\because\ x = \frac{\lambda D}{2\,d}\right)$

$= 54600 \times 10^{-7} rad$

θ (in degree) $= \frac{180}{\pi} \times 546 \times 10^{-5}$

$= \frac{180}{22} \times 7 \times 546 \times 10^{-5} \approx \frac{0.32}{2} = 0.16^o$

24. (a)



Distance between two slits i.e., S_1 and S_2

d = $(2\ \tan\ \theta / 2)D$

For small angles θ , $\tan\theta \approx \theta$

$\Longrightarrow$ d = $2 \times \frac{\theta}{2} \times D = D\theta$ or $\frac{D}{d} = \frac{1}{\theta}$

Fringe width, $\beta = \frac{\lambda D}{d} = \frac{\lambda}{\theta}$

25. (a)

In liquid position of 10th bright fringe ,

$x_n = \frac{n\lambda_l D}{d}$

λ_l = wavelength in liquid .

$\because$ Position of dark fringe = $(2n-1)\frac{\lambda D}{2\,d}$ ... (i)

In vacuum position of 6th dark fringe

$= \frac{11\lambda_{air}\,D}{2d}$

[n= 6 in Eq (i)]

10th bright fringe in liquid is located at 6th dark fringe in air ,

$\Longrightarrow \frac{10\,\lambda_l\,D}{d} = \frac{11\,\lambda_{air}\,D}{2d} \Longrightarrow \frac{\lambda_l}{\lambda_{air}} = \frac{5.5}{10}$

$\frac{\lambda_l}{\lambda_{air}} = \frac{\lambda_{air}}{\lambda_l} \Longrightarrow \frac{1}{\mu_l} = \frac{5.5}{10}$

Or $\mu_l = \frac{10}{5.5} = \frac{20}{11}$ = 1.8

26. (b)

$I = I_{max}cos^2\frac{\phi}{2}$ -------- (i)

$I = \frac{I_{max}}{2}$ ------ (ii)

$\therefore$ (i) and (ii) , $\phi = \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{2}$

or path difference , $\Delta x = \left(\frac{\lambda}{2\,\pi}\right).\phi$

$\therefore\ \Delta x = \frac{\lambda}{4}, \frac{3\,\lambda}{4}, \frac{5\,\lambda}{4}$ ..... $\left(\frac{2n+1}{4}\right)\lambda$

$n = 0,1,2 \ldots\ldots$

27. (c)

Fringe width $\beta_1 = \frac{\lambda D}{d}$

$\beta_2 = \lambda\left(\frac{2D}{2d}\right) = \frac{\lambda D}{d}$

$\Longrightarrow \beta_1 = \beta_2$

28. (b)

In YDSE

Intensity , $I = I_{max}cos^2\frac{\Delta\phi}{2}$

$\Longrightarrow \frac{I_{max}}{2} = I_{max}cos^2\frac{\Delta\phi}{2}$

$cos^2\frac{\Delta\phi}{2} = \frac{1}{2} \Longrightarrow \frac{\Delta\phi}{2} = \left(\frac{2n+1}{4}\right)\pi$, n = 0,1,2,..

$\Delta\phi = \left(\frac{2n+1}{4}\right)\pi$

$\Longrightarrow \Delta x = \frac{\Delta\phi}{2\pi} \times \lambda$ (Δx is path difference)

$\left(\frac{2n+1}{2}\right)\pi \times \left(\frac{2n+1}{4}\right)\lambda$

29. (c)

$I = 4I_0cos^2\frac{\phi}{2}\left(\phi = \frac{2\pi}{\lambda} \times \lambda\right)$

$K = 4\,I_0cos^2\pi$

$K = 4\,I_0$ ----------(i)

Second case

$K' = 4\,I_0cos^2\left(\frac{\pi/2}{2}\right)\left(\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{4}\right)$

$= 4\,I_0cos^2(\pi/4)$

$K' = 2\,I_0$

Comparing Eqs. (i) and (ii)

$K' = K/2$

30. (c)

The direction in which the first minima occurs is θ (say),

$esin\theta = \lambda\ or\ e\theta = \lambda\ or = \frac{\lambda}{e}$

$(\because\ \theta = sin\theta, when\ \theta\ is\ small)$

Width of the central maxima

$= 2b\theta + e = \frac{2\lambda b}{e} \pm e$

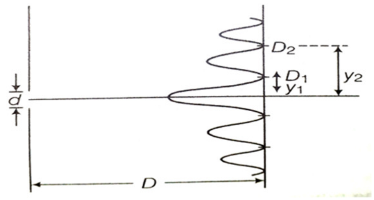
31. (a) Width of central maximum

$(\Delta y_0) = 2y = \frac{2\lambda D}{d}$ ....(i)

Width of 1st order secondary maxima

= Distance between $D_1\ and D_2$(consecutive dark bands)

$= y_2 - y_1$



For secondary minima (or dark band) path difference

$= d\ sin\theta = m\lambda$ (where,m= 1,2,3 …..)

Position of 1st dark band

Path difference= $\frac{y_1 d}{D} = \lambda\ or\ \ y_1 = \frac{\lambda D}{d}$

Position of 2nd dark band

Path difference= $\frac{y_2\ d}{D} = 2\lambda \Rightarrow y_2 = \frac{2\lambda D}{d}$

$\therefore$ Width of secondary maxima (Δy_1)

$\Rightarrow\ \ \Delta y_1 = y_2 - y_1\ or\ \Delta y_1 = \frac{\lambda D}{d} = y$

Thus, width of other secondary maxima is half that of central maxima

Or $\frac{\Delta y_0}{\Delta y_1} = \frac{2}{1}$

32. (c)

For minima,

$$a\ sin\theta = n\lambda$$

$\Rightarrow\ \ a\ sin30° = (1)\lambda\ \ \ (n = 1)$

$\Rightarrow\ \ a = 2\lambda\ \ \ \left\{\therefore sin30° = \frac{1}{2}\right\}$ …(i)

For 1st secondary maxima

$\Rightarrow\ \ a\ sin\theta_1 = \frac{3\lambda}{2} \Rightarrow sin\theta_1 = \frac{3\lambda}{2a}$ ….(ii)

Substitute value of a from Eq(i) to Eq.(ii), we get

$$\text{Sin}\ \theta_1 = \frac{3\lambda}{4\lambda} \Rightarrow sin\theta_1 = \frac{3}{4}$$

$$\theta_1 = sin^{-1}\frac{3}{4}$$

33. (b)

34. (c) Using violet light

Slit width $= d, \lambda_1 = 400 \times 10^{-9}\ m$

Width of diffraction pattern (Central maxima)

$$2y = \frac{2\lambda_1 D}{d} \quad \text{...(i)}$$

Slit width $= \frac{d}{2}$ (as half covered)

$$\lambda_2 = 600 \times 10^{-9}\ m$$

Width of diffraction pattern (Central maxima)

$$= 2y' = \frac{2\lambda_2 D}{(d/2)} \quad \text{...(ii)}$$

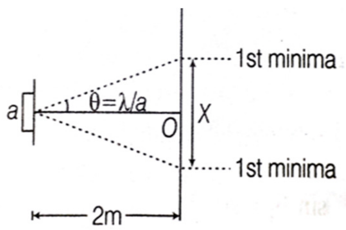
From Eqs. (i) and (ii), $\frac{y}{y'} = \frac{\lambda_1}{2\lambda_2}$

$\Rightarrow\ \ \frac{y}{y'} = \frac{400}{600\times 2} = \frac{2}{3\times 2} = \frac{1}{3} \Rightarrow y' = 3y$

35. (d)

From the figure, tan $\theta = \frac{x/2}{2}$

For small θ and when θ is counted in rad, tan $\theta \simeq \theta$



Width of central maximum $= \frac{2\lambda D}{d} = 24\ m$

So, $\theta \simeq \frac{x/2}{2} \Rightarrow \frac{\lambda}{9} \simeq \frac{x}{4}$

$$x \simeq \frac{4\lambda}{a} \simeq \frac{4\times 600\times 10^{-9}}{10^{-3}}$$

$$\simeq 24 \times 10^{-4}\ m \simeq 2.4 \times 10^{-3}\ m$$

$\Rightarrow\ \ \simeq$ 2.4 mm

36. (b)

In water angular width $\theta_w = 0.2°$ (given)

$\theta_w = \frac{\lambda_{water}}{d}$ ...(i)

$\mu_{water} =$ refractive index of water

In air,

$\theta_w = \frac{\lambda_{air}}{d}$ ....(ii)

On dividing Eq. (i) from Eq. (ii), we get

$\frac{\theta_w}{\theta_{air}} = \frac{\lambda_{water}}{\lambda_{air}}$

Or $\frac{\theta_w}{\theta_{air}} = \frac{\mu_{air}}{\mu_{water}} = \frac{1}{\mu_{water}}$ $\left(\because \frac{\lambda_{air}}{\lambda_{water}} = \frac{\mu_{water}}{\mu_{air}}\right)$

$\Rightarrow \theta_{air} = \mu_{water}\theta_w = \frac{4}{3} \times 0.2° \approx 0.28°$

37. (b)

The angular resolution of the telescope is determined by the objective of the telescope.

38. (c)

39. (a) In Fresnel biprism experiment, the actual distance of separation between the two slits,

$$d = \sqrt{d_1 d_2} = \sqrt{25 \times 16} = 20\ cm$$

40. (b)

41. (a)

Plane of vibration is perpendicular to the direction of propagation and also perpendicular to plane of polarization. Thus the angle between plane of polarization and direction of vibration is 0° i.e, they are parallel.

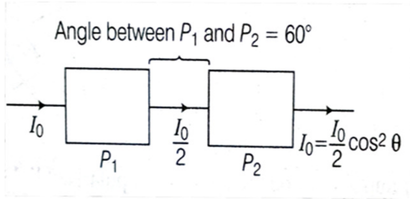
42. (a)

In unpolarised beam, vibrations are probable in all directions in a plane perpendicular to the direction of propagation. Therefore, θ can have any value from 0 to 2π.

$[cos^2\,\theta]_{av} = \frac{1}{2\pi}\int_0^{2\pi} cos^2\theta\, d\theta = \frac{1}{2\pi}\int_0^{2\pi}\left(\frac{1+cos2\theta}{2}\right) d\theta = \frac{1}{2}$

So, using law of malus, $I = I_0 cos^2\theta \Rightarrow I_0 = I_0 \times \frac{1}{2} = \frac{I_0}{2}$

43. (d)

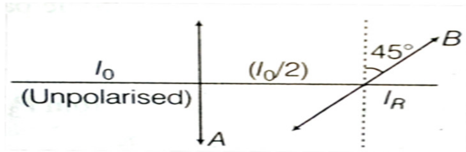


Intensity of light emerging from P_2 $is\ I = \frac{I_0}{2} cos^2\,\theta$

Where, $\theta = < angle\ between\ P_1\ andP_2$

So, $I = \frac{I_0}{2} cos^2\,60° = \frac{I_0}{8}$

44. (c)



According to Malus law,

$$I_R = \left(\frac{I_0}{2}\right) cos^2(45°) = \frac{I_0}{2} \times \frac{1}{2} = \frac{I_0}{4}$$

45. (a)

If unpolarised light is incident at polarizing angle, then reflected light is completely i.e, 100% polarized perpendicular to the plane of incidence.

46. (b)

tan $i_B = \mu, where i_B$
= polarising or Brewster's angle

$\Rightarrow i_B = tan^{-1}(\mu) = tan^{-1}(\sqrt{3}) = 60°$

47. (a)

Critical angle, $i_c = sin^{-1}\left(\frac{4}{5}\right)$

$\therefore$ sin $i_c = \frac{4}{5}$

As $\mu = \frac{1}{sin\ i_c} = \frac{5}{4}$

According to Brewster's law.

tan $i_p = \mu$

Where, i_p is the polarizing angle

$\therefore \quad \tan i_p = \frac{5}{4} \Rightarrow i_p = tan^{-1}\left(\frac{5}{4}\right)$

48. (c)

49. (b)

Given, wavelength of $H_{\propto}, \lambda = 6563 \times 10^{-10} m$
Red shift $\Delta\lambda$ = 15 Å

The star is found to be red -shifed , hence star is receding away from earth and Doppler's shift is negative

$\Delta\lambda = -\frac{v\,\lambda}{c} \quad \Rightarrow \quad v = -\frac{\Delta\lambda\ .\ c}{\lambda} = \frac{15 \times 3 \times 10^8}{6563}$
$v = -6.86 \times 10^5 ms^{-1}$
Negative sign show that the star is receding away from earth

50. (c)

Given ,wavelength of light$\lambda = 500nm = 500 \times 10^{-9}\ m$

$D = 1\ m, n = 1, x = 2.5\ mm = 2.5 \times 10^{-3}\ m$

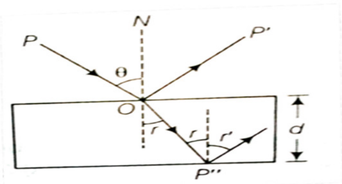
Distance of n^{th} minimum from the centre, $x = \frac{nD\lambda}{d}$

$d = \frac{nD\lambda}{x} = \frac{1\times1\times500\times10^{-9}}{2.5\times10^{-3}} = 2 \times 10^{-4}\ m \Rightarrow d = 0.2\ mm$

Thus, the width of the slit of 0.2 mm

51. (a)

Consider the diagram, the ray *(P)* is incident at an angle 0 and gets reflected in the direction *P'* and refracted in the direction *P''*. Due to reflection from the glass medium, there is a phase change of π.



Time taken to travel along *OP''*

$\Delta t = \frac{OP''}{v} = \frac{d/\cos r}{c/n} = \frac{nd}{c\,cosr}$

From Snell's law, $n = \frac{\sin\theta}{\sin r}$

$\Rightarrow \qquad \sin r = \frac{\sin\theta}{n}$

$\cos r = \sqrt{1 - sin^2 r} = \sqrt{1 - \frac{sin^2\theta}{n^2}}$

$\therefore \quad \Delta t = \frac{nd}{c\left(1 - \frac{sin^2\theta}{n^2}\right)^{1/2}} = \frac{n^2 d}{c}\left(1 - \frac{sin^2\theta}{n^2}\right)^{-1/2}$

Phase difference $= \Delta\phi = \frac{2\pi}{\lambda} \times \Delta t$

$= \frac{2\pi nd}{\lambda}\left(1 - \frac{sin^2\theta}{n^2}\right)^{-1/2}$

So, net phase difference $= \Delta\phi + \pi$

$= \frac{4\pi d}{\lambda}\left(1 - \frac{1}{n^2} sin^2\theta\right)^{-1/2} + \pi$

52. (b)

The resultant disturbance at a point will be calculated by sun of disturbances due to individual sources.

Consider the disturbances at the receiver R_1 which is at a distance *d* from *B.*

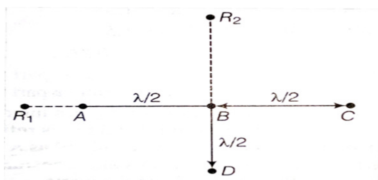
Let the wave at R_1 because of A be $Y_A = a\ cos\ \omega t$. The path difference of the signal from *A* with that from *B* is $\lambda/2$ and hence, the phase difference is π.

Thus, the wave at R_1 because of *B* is

$Y_B = acos(\omega t - \pi) = -acos\ \omega t$

The path difference of the signal from C with that from *A* is λ and hence the phase difference is 2π .

The , the wave at R_1 because of *C* is Y_C = a $cos\ (\omega t - 2\pi)$ = a $cos\ \omega t$



The path difference between signal from D with that of A is

$\sqrt{d^2 + \left(\frac{\lambda}{2}\right)^2} - (d - \lambda/2)$ = d

$\left(1 + \frac{\lambda}{4d^2}\right)^{1/2}$ − d + $\frac{\lambda}{2}$

= d$\left(1 + \frac{\lambda^2}{8\,d^2}\right)^{1/2} - d + \frac{\lambda}{2} \approx \frac{\lambda}{2} (\because d \gg \lambda)$

Therfore , phase difference is π

∴ Y_D = a cos $(\omega\, t - \pi)$ − a cos $\omega\, t$