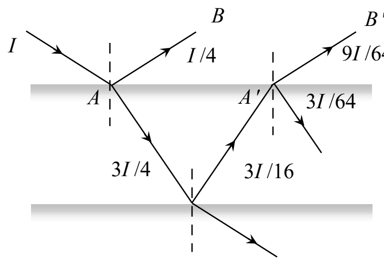
Critical Thinking Questions

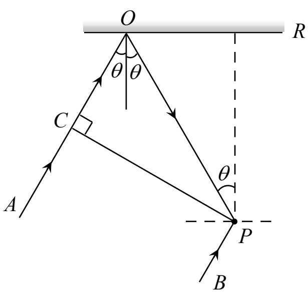
1. (d) From figure $I_1 = \frac{I}{4}$ and $I_2 = \frac{9I}{64}$ $\Rightarrow$ $\frac{I_2}{I_1} = \frac{9}{16}$



By using $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_2}{I_1}}+1}{\sqrt{\frac{I_2}{I_1}}-1}\right) = \left(\frac{\sqrt{\frac{9}{16}}+1}{\sqrt{\frac{9}{16}}-1}\right) = \frac{49}{1}$

2. (a) The cylindrical surface touches the glass plate along a line parallel to axis of cylinder. The thickness of wedge shaped film increases on both sides of this line. Locus of equal path difference are the lines running parallel to the axis of the cylinder. Hence straight fringes are obtained.

3. (b) $\because PR = d \Rightarrow PO = d\sec\theta$ and $CO = PO\cos 2\theta = d\sec\theta\cos 2\theta$ is



Path difference between the two rays

$\Delta = CO + PO = (d\sec\theta + d\sec\theta\cos 2\theta)$

Phase difference between the two rays is

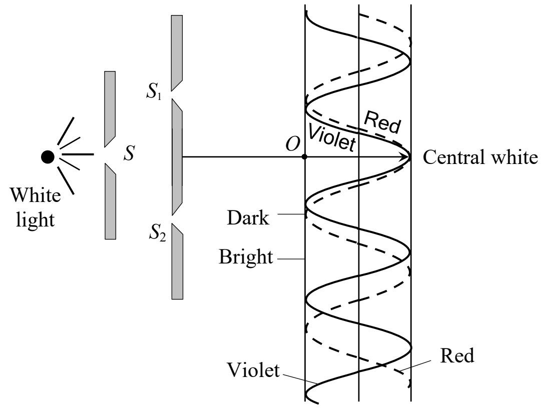
$\phi = \pi$ (One is reflected, while another is direct)

Therefore condition for constructive interference should be $\Delta = \frac{\lambda}{2}, \frac{3\lambda}{2}$ ......

or $d\sec\theta(1+\cos 2\theta) = \frac{\lambda}{2}$

or $\frac{d}{\cos\theta}(2\cos^2\theta) = \frac{\lambda}{2} \Rightarrow \cos\theta = \frac{\lambda}{4d}$

4. (c) In young's double slit experiment, if white light is used in place of monochromatic light, then the central fringe is white and some coloured fringes around the central fringe are formed.

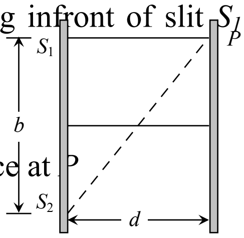


Since $\beta_{red} > \beta_{violet}$ etc., the bright fringe of violet colour forms first and that of the red forms later.

It may be noted that, the inner edge of the dark fringe is red, while the outer edge is violet. Similarly, the inner edge of the bright fringe is violet and the outer edge is red.

5. (a) In conventional light source, light comes from a large number of independent atoms, each atom emitting light for about 10^{-9} *sec* *i.e.* light emitted by an atom is essentially a pulse lasting for only 10^{-9} *sec*. Light coming out from two slits will have a fixed phase relationship only for 10^{-9} *sec*. Hence any interference pattern formed on the screen would last only for 10^{-9} *sec*, and then the pattern will change. The human eye can notice intensity changes which last at least for a tenth of a second and hence we will not be able to see any interference pattern. In stead due to rapid changes in the pattern, we will only observe a uniform intensity over the screen.

6. (a,c) Path difference between the rays reaching infront of slit S_1 is.



$S_1P - S_2P = (b^2 + d^2)^{1/2} - d$

For distructive interference at P

$S_1P - S_2P = \frac{(2n-1)\lambda}{2}$

i.e., $(b^2 + d^2)^{1/2} - d = \frac{(2n-1)\lambda}{2}$

$\Rightarrow d\left(1 + \frac{b^2}{d^2}\right)^{1/2} - d = \frac{(2n-1)\lambda}{2}$

$\Rightarrow d\left(1 + \frac{b^2}{2d^2} + ...\right) - d = \frac{(2n-1)\lambda}{2}$

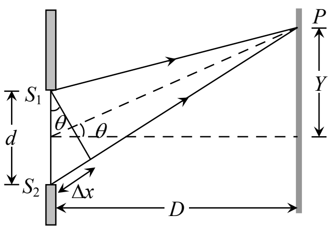
(Binomial Expansion)

$\Rightarrow \frac{b}{2d} = \frac{(2n-1)\lambda}{2} \Rightarrow \lambda = \frac{b^2}{(2n-1)d}$

For $n = 1, 2............, \lambda = \frac{b^2}{d}, \frac{b^2}{3d}$

7. (a)

8. (a,b) For microwave $\lambda = \frac{c}{f} = \frac{3 \times 10^8}{10^6} = 300\ m$



As $\Delta x = d\sin\theta$

Phase difference $\phi = \frac{2\pi}{\lambda}$(Path difference)

$= \frac{2\pi}{\lambda}(d\sin\theta) = \frac{2\pi}{300}(150\sin\theta) = \pi\sin\theta$

$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

Here $I_1 = I_2$ and $\phi = \pi\sin\theta$

$\therefore I_R = 2I_1[1 + \cos(\pi\sin\theta)] = 4I_1\cos^2\left(\frac{\pi\sin\theta}{2}\right)$

I_R will be maximum when $\cos^2\left(\frac{\pi\sin\theta}{2}\right) = 1$

$\therefore (I_R)_{\max} = 4I_1 = I_o$

Hence $I = I_o\cos^2\left(\frac{\pi\sin\theta}{2}\right)$

If $\theta = 0$, then $I = I_o\cos\theta = I_o$

If $\theta = 30°$, then $I = I_o\cos^2(\pi/4) = I_o/2$

If $\theta = 90°$, then $I = I_o\cos^2(\pi/2) = 0$

9. (d) $I = a_1^2 + a_2^2 + 2a_1a_2\cos\phi$

Put $a_1^2 + a_2^2 = A$ and $a_1a_2 = B$, $\therefore I = A + B\cos\phi$

10. (d) Since *P* is ahead of *Q* by 90° and path difference between *P* and *Q* is $\lambda/4$. Therefore at *A*, phase difference is zero, so intensity is 4*I*. At *C* it is zero and at *B*, the phase difference is 90°, so intensity is 2*I*.

11. (b) By using phase difference $\phi = \frac{2\pi}{\lambda}(\Delta)$

For path difference λ, phase difference $\phi_1 = 2\pi$ and for path difference $\lambda/4$, phase difference $\phi_2 = \pi/2$.

Also by using $I = 4I_0\cos^2\frac{\phi}{2}$ $\Rightarrow$ $\frac{I_1}{I_2} = \frac{\cos^2(\phi_1/2)}{\cos^2(\phi_2/2)}$

$\Rightarrow \frac{K}{I_2} = \frac{\cos^2(2\pi/2)}{\cos^2\left(\frac{\pi/2}{2}\right)} = \frac{1}{1/2} \Rightarrow I_2 = \frac{K}{2}$.

12. (d) If shift is equivalent to *n* fringes then

$n = \frac{(\mu-1)t}{\lambda} \Rightarrow n \propto t \Rightarrow \frac{t_2}{t_1} = \frac{n_2}{n_1} \Rightarrow t_2 = \frac{n_2}{n_1} \times t$

$t_2 = \frac{20}{30} \times 4.8 = 3.2\ mm.$

13. (a) According to given condition

$(\mu-1)t = n\lambda$ for minimum *t, n* =1

So, $(\mu-1)t_{\min} = \lambda$

$t_{\min} = \frac{\lambda}{\mu-1} = \frac{\lambda}{1.5-1} = 2\lambda$

14. (a) $\Delta\lambda = \lambda\frac{v}{c}$ and $v = r\omega$

$v = 7 \times 10^8 \times \frac{2\pi}{25 \times 24 \times 3600}$, $c = 3 \times 10^8\ m/s$

$\therefore \Delta\lambda = 0.04\ \mathring{A}$

15. (b) $v = \frac{c\Delta\lambda}{\lambda} = \frac{3 \times 10^8 \times (706 - 656)}{656} = \frac{1500}{656} \times 10^7$

$= 2 \times 10^7\ m/s$

16. (b) In this case, we can assume as if both the source and the observer are moving towards

each other with speed v. Hence $v' = \frac{c-u_o}{c-u_s}v = \frac{c-(-v)}{c-v}v = \frac{c+v}{c-v}v$

$= \frac{(c+v)(c-v)}{(c-v)^2}v = \frac{c^2-v^2}{c^2+v^2-2vc}v$

Since $v<<c$, therefore $v' = \frac{c^2}{c^2-2vc} = \frac{c}{c-2v}v$

17. (a) $\Delta\lambda = \lambda.\frac{v}{c}$ where $v = r\omega = r\times\left(\frac{2\pi}{T}\right)$

$\therefore \Delta\lambda = \frac{4320\times7\times10^8\times2\times3.14}{3\times10^8\times22\times86400} = 0.033\mathring{A}$

18. (a) $\beta = \frac{\lambda D}{d} \Rightarrow \beta \propto D$

$\Rightarrow \frac{\beta_1}{\beta_2} = \frac{D_1}{D_2} \Rightarrow \frac{\beta_1-\beta_2}{\beta_2} = \frac{D_1-D_2}{D_2} \Rightarrow$

$\frac{\Delta\beta}{\Delta D} = \frac{\beta_2}{D_2} = \frac{\lambda_2}{d_2}$

$= \lambda_2 = \frac{3\times10^{-5}}{5\times10^{-2}}\times10^{-3} = 6\times10^{-7}m = 6000\mathring{A}$

19. (a) P is the position of 11th bright fringe from Q. From central position O, P will be the position of 10th bright fringe.

Path difference between the waves reaching at $P = S_1B = 10\,\lambda = 10\times6000\times10^{-10} = 6\times10^{-6}m$.

20. (b) Resultant intensity $I = I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$

At central position with coherent source (and $I_1 = I_2 = I_0$

$I_{con} = 4I_0$ ... (i)

In case of incoherent at a given point, ϕ varies randomly with time so $(\cos\phi)_{av} = 0$

$\therefore I_{Incoh} = I_1 + I_2 = 2I_0$ ... (ii)

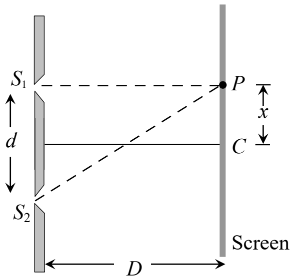
Hence $\frac{I_{coh}}{I_{Incoh}} = \frac{2}{1}$.

21. (a, d) These waves are of same frequencies and they are coherent

22. (c) Fringe width $\beta \propto \lambda$. Therefore, λ and hence β decreases 1.5 times when immersed in liquid. The distance between central maxima and 10th maxima is 3 cm in vacuum. When immersed in liquid it will reduce to 2 cm. Position of central maxima will not change while 10th maxima will be obtained at $y = 4cm$.

23. (a) Suppose P is a point infront of one slit at which intensity is to be calculated from figure it is clear that $x = \frac{d}{2}$. Path difference between the waves reaching at P

$\Delta = \frac{xd}{D} = \frac{\left(\frac{d}{2}\right)d}{10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$



Hence corresponding phase difference $\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{4} = \frac{\pi}{2}$

Resultant intensity at P

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

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

24. (d) If $d\sin\theta = (\mu-1)t$, central fringe is obtained at O

If $d\sin\theta > (\mu-1)t$, central fringe is obtained above O and

If $d\sin\theta < (\mu-1)t$, central fringe is obtained below O.

25. (b) For maximum intensity on the screen

$d\sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n\lambda}{d} = \frac{n(2000)}{7000} = \frac{n}{3.5}$

Since maximum value of $\sin\theta$ is 1

So $n = 0, 1, 2, 3,$ only. Thus only seven maximas can be obtained on both sides of the screen.

26. (c) From the given data, note that the fringe width (β_1) for $\lambda_1 = 900\,nm$ is greater than fringe width (β_2) for $\lambda_2 = 750\,nm$. This means that at though the central maxima of the two coincide, but first maximum for $\lambda_1 = 900\,nm$ will be further away from the first maxima for $\lambda_2 = 750\,nm$, and so on. A stage may come when this mismatch equals β_2, then again maxima of $\lambda_1 = 900\,nm$, will coincide with a maxima of $\lambda_2 = 750\,nm$, let this

correspond to n^{th} order fringe for λ_1. Then it will correspond to $(n+1)^{th}$ order fringe for λ_2.

Therefore $\frac{n\lambda_1 D}{d} = \frac{(n+1)\lambda_2 D}{d}$

$\Rightarrow n \times 900 \times 10^{-9} = (n+1) 750 \times 10^{-9} \Rightarrow n = 5$

Minimum distance from

Central maxima $= \frac{n\lambda_1 D}{d} = \frac{5 \times 900 \times 10^{-9} \times 2}{2 \times 10^{-3}}$

$= 45 \times 10^{-4} m = 4.5 \, mm$

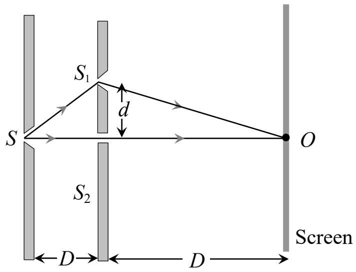
27. (c) Shift $= \frac{\beta}{\lambda}(\mu - 1)t$

$\Rightarrow 7\beta = \frac{\beta}{\lambda}(\mu - 1)t \Rightarrow t = \frac{7\lambda}{(\mu - 1)} = \frac{7 \times 600}{(1.5 - 1)} = 8400 \, nm.$

28. (c) Path difference between the waves reaching at P, $\Delta = \Delta_1 + \Delta_2$

where $\Delta_1 =$ Initial path difference

$\Delta_2 =$ Path difference between the waves after emerging from slits.



$\Delta_1 = SS_1 - SS_2 = \sqrt{D^2 + d^2} - D$

and $\Delta_2 = S_1O - S_2O = \sqrt{D^2 + d^2} - D$

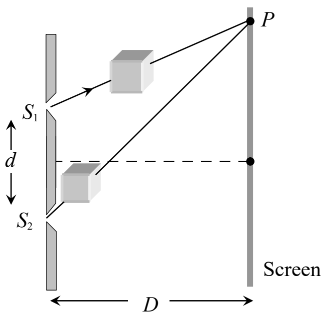
$\therefore \ \Delta = 2\left\{(D^2 + d^2)^{\frac{1}{2}} - D\right\} = 2\left\{(D^2 + \frac{d^2}{2D}) - D\right\}$

$= \frac{d^2}{D}$ (From Binomial expansion)

For obtaining dark at O, Δ must be equals to $(2n-1)\frac{\lambda}{2}$ *i.e.* $\frac{d^2}{D} = (2n-1)\frac{\lambda}{2} \Rightarrow d\sqrt{\frac{(2n-1)\lambda D}{2}}$

For minimum distance $n = 1$ so $d = \sqrt{\frac{\lambda D}{2}}$

29. (a) Shift $\Delta x = \frac{\beta}{\lambda}(\mu - 1)t$



Shift due to one plate $\Delta x_1 = \frac{\beta}{\lambda}(\mu_1 - 1)$

Shift due to another path $\Delta x_2 = \frac{\beta}{\lambda}(\mu_2 - 1)t$

Net shift $\Delta x = \Delta x_2 - \Delta x_1 = \frac{\beta}{\lambda}(\mu_2 - \mu_1)t$ …..(i)

Also it is given that $\Delta x = 5\beta$ …..(ii)

Hence $5\beta = \frac{\beta}{\lambda}(\mu_1 - \mu_2)t$

$\Rightarrow t = \frac{5\lambda}{(\mu_2 - \mu_1)} = \frac{5 \times 4800 \times 10^{-10}}{(1.7 - 1.4)} = 8 \times 10^{-6} m = 8 \mu m.$

30. (b) For maxima $2\pi n = \frac{2\pi}{\lambda}(XO) - 2\pi l$

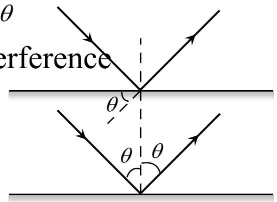
or $\frac{2\pi}{\lambda}(XO) = 2\pi(n + l)$ or $(XO) = \lambda(n + l)$

31. (c) Path difference $= 2d\sin\theta$

$\therefore$ For constructive interference

$2d\sin\theta = n\lambda$

$\Rightarrow \theta = \sin^{-1}\left(\frac{n\lambda}{2d}\right)$

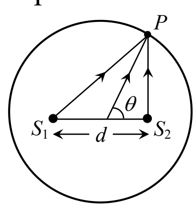


32. (b) Here path difference at a point P on the circle is given by

$\Delta x = d\cos\theta$ ….. (i)

For maxima at P

$\Delta x = n\lambda$ ….. (ii)



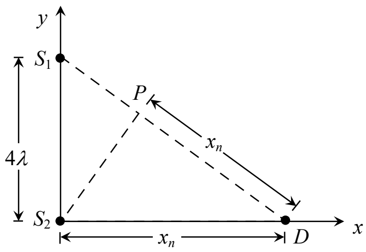
From equation (i) and (ii)

$n\lambda = d\cos\theta \Rightarrow \theta \cos^{-1}\left(\frac{n\lambda}{d}\right) = \cos^{-1}\left(\frac{4\lambda}{d}\right)$

33. (b) From $\Delta S_1 S_2 D$,

$(S_1D)^2 = (S_1S_2)^2 + (S_2D)^2$

$(S_1P + PD)^2 = (S_1S_2)^2 + (S_2D)^2$



Here S_1P is the path difference $= n\lambda$ for maximum intensity.

$\therefore (n\lambda + x_n)^2 = (4\lambda)^2 + (x_n)^2$

or $x_n = \dfrac{16\lambda^2 - n^2\lambda^2}{2n\lambda}$

Then $x_1 = \dfrac{16\lambda^2 - \lambda^2}{2\lambda} = 7.5\lambda$

$x_2 = \dfrac{16\lambda^2 - 4\lambda^2}{4\lambda} = 3\lambda$

$x_3 = \dfrac{16\lambda^2 - 9\lambda^2}{6\lambda} = \dfrac{7}{6}\lambda$

$x_4 = 0$.

$\therefore$ Number of points for maxima becomes 3.

34. (a) $I_0 = R^2 = \dfrac{R_2^2}{4}$

Number of HPZ covered by the disc at $b = 25\,cm$ $n_1 b_1 = n_2 b_2$

$n_2 = \dfrac{n_1 b_1}{b_2} + \dfrac{1\times 1}{0.25} = 4$

Hence the intensity at this point is

$I = R^2 = \left(\dfrac{R_5}{2}\right)^2 = \left(\dfrac{R_5}{R_4}\times\dfrac{R_4}{R_3}\times\dfrac{R_3}{R_2}\right)^2 \times \left(\dfrac{R_2}{2}\right)^2$

or $1 = [0.9]^6$

$I_1 = 0.531\, I_0$

Hence the correct answer will be (a).

35. (b) $I_A = R_1^2$

$I_B = (R_1 - R_2)^2 = R_1^2\left(1 - \dfrac{R_2}{R_1}\right)^2 = R_1^2\left(1 - \dfrac{3}{4}\right)^2 = \dfrac{R_1^2}{16}$

$I_C = (R_1 - R_2 + R_3)^2 = R_1^2\left(1 - \dfrac{R_2}{R_1} + \dfrac{R_3}{R_1}\right)^2$

$= R_1^2\left(1 - \dfrac{R_2}{R_1} + \dfrac{R_3}{R_2}\times\dfrac{R_2}{R_1}\right)^2$

$= R_1^2\left(1 - \dfrac{3}{4} + \dfrac{3}{4}\times\dfrac{3}{4}\right)^2 = \left(\dfrac{13}{16}\right)^2 R_1^2 = \dfrac{169}{256}R_1^2$

$\therefore\ I_A : I_B : I_C = R_1^2 : \dfrac{R_1^2}{16} : \dfrac{169}{256}R_1^2 = 256 : 16 : 169$

36. (d) $I = \dfrac{R_2^2}{4}$ given $n_1 b_1 = n_2 b_2 \Rightarrow 1\times 200 = n_2 \times 25$

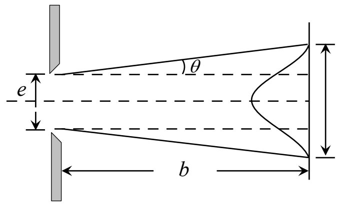
$\therefore n_2 = 8\ HPZ$

$\therefore I = \left(\dfrac{R_9}{2}\right)^2$

$= \left(\dfrac{R_9}{R_8}\times\dfrac{R_8}{R_7}\times\dfrac{R_7}{R_6}\times\dfrac{R_6}{R_5}\times\dfrac{R_5}{R_4}\times\dfrac{R_4}{R_3}\times\dfrac{R_3}{R_2}\times\dfrac{R_2}{R_2}\right)^2$

$= \left(\dfrac{R_9}{R_2}\right)^2 I$

37. (c) The direction in which the first minima occurs is θ (say). Then $e\sin\theta = \lambda$ or $e\theta = \lambda$ or, $\theta = \dfrac{\lambda}{e}$ ($\because\ \theta = \sin\theta$ when θ small)



Width of the central maximum $= 2b\theta + e = 2b.\dfrac{\lambda}{e} + e$

38. (b) Angular width $\beta = \dfrac{2\lambda}{d} \Rightarrow \beta \propto \lambda$

$\Rightarrow \dfrac{\beta_1}{\beta_2} = \dfrac{\lambda_1}{\lambda_2} \Rightarrow \dfrac{\beta}{\frac{70}{100}\beta} = \dfrac{6000}{\lambda_2} \Rightarrow \lambda_2 = 4200\,\mathring{A}$

39. (a) In a single slit diffraction experiment, position of minima is given by $d\sin\theta = n\lambda$

So for first minima of red $\sin\theta = 1\times\left(\dfrac{\lambda_R}{d}\right)$

and as first maxima is midway between first and second minima, for wavelength λ', its position will be

$d\sin\theta' = \dfrac{\lambda' + 2\lambda'}{2} \Rightarrow \sin\theta' = \dfrac{3\lambda'}{2d}$

According to given condition $\sin\theta = \sin\theta'$

$\Rightarrow \lambda' = \dfrac{2}{3}\lambda_R$ so $\lambda' = \dfrac{2}{3}\times 6600 = 440\,nm = 4400\,\mathring{A}$

40. (c) $I = I_0\left[\dfrac{\sin\alpha}{\alpha}\right]^2$, where $\alpha = \dfrac{\phi}{2}$

For n^{th} secondary maxima $d\sin\theta = \left(\dfrac{2n+1}{2}\right)\lambda$

$\Rightarrow \alpha = \dfrac{\phi}{2} = \dfrac{\pi}{\lambda}[d\sin\theta] = \left(\dfrac{2n+1}{2}\right)\pi$

$\therefore\ I = I_0\left[\dfrac{\sin\left(\frac{2n+1}{2}\right)\pi}{\left(\frac{2n+1}{2}\right)\pi}\right]^2 = \dfrac{I_0}{\left\{\frac{(2n+1)}{2}\pi\right\}^2}$

So $I_0 : I_1 : I_2 = I_0 : \dfrac{4}{9\pi^2}I_0 : \dfrac{4}{25\pi^2}I_0$

$= 1 : \dfrac{4}{9\pi^2} : \dfrac{4}{25\pi^2}$

41. (d) For a grating $(e + d)\sin\theta_n = n\lambda$

where $(e+d)=$ grating element

$\sin\theta_n = \frac{n\lambda}{(e+d)}$

For $n=1$, $\sin\theta_1 = \frac{\lambda}{(e+d)} = \sin 32°$

This is more than 0.5. Now $\sin\theta_2$ will be more than 2×0.5, which is not possible.

42. (a) The film appears bright when the path difference

$(2\mu t\cos r)$ is equal to odd multiple of $\frac{\lambda}{2}$

i.e. $2\mu t\cos r = (2n-1)\lambda/2$ where $n=1, 2, 3$ .....

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

$= \frac{4\times 1.4\times 10{,}000\times 10^{-10}\times\cos 0}{(2n-1)} = \frac{56000}{(2n-1)}Å$

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

The wavelength which are not within specified range are to be refracted.

43. (a) Total phase difference

= Initial phase difference + Phase difference due to path

$= 66° + \frac{360°}{\lambda}\times\Delta x = 66° + \frac{360°}{\lambda}\times\frac{\lambda}{4} = 66° + 90 = 156°$

44. (a) $I = 4I_0\cos^2\frac{\phi}{2}$

At central position $I_1 = 4I_0$ ……(i)

Since the phase difference between two successive fringes is 2π, the phase difference between two points separated by a distance equal to one quarter of the distance between the two, successive fringes is equal to $\delta = (2\pi)\left(\frac{1}{4}\right) = \frac{\pi}{2}$ radian

$\Rightarrow I_2 = 4I_0\cos^2\left(\frac{\frac{\pi}{2}}{2}\right) = 2I_0$ ……(ii)

Using (i) and (ii), $\frac{I_1}{I_2} = \frac{4I_0}{2I_0} = 2$

45. (b) $I_D = \varepsilon_0\frac{d\phi_E}{dt} = \varepsilon_0\frac{EA}{t} = \varepsilon_0\left(\frac{V}{d}\right).\frac{A}{t}.$

$= \frac{8.85\times 10^{-12}\times 400\times 60\times 10^{-4}}{10^{-3}\times 10^{-6}} = 1.602\times 10^{-2}\,amp$

46. (d) Electric field $E = \frac{V}{l} = \frac{iR}{l}$ (R = Resistance of wire)

Magnetic field at the surface of wire $B = \frac{\mu_0 i}{2\pi a}$

(a = radius of wire)

Hence poynting vector, directed radially inward is given by $S = \frac{EB}{\mu_0} = \frac{iR}{\mu_0 l}.\frac{\mu_0 i}{2\pi a} = \frac{i^2R}{2\pi al}$

47. (b) Average energy density of electric field is given by

$u_e = \frac{1}{2}\varepsilon_0E^2 = \frac{1}{2}\varepsilon_0\left(\frac{E_0}{\sqrt{2}}\right)^2 = \frac{1}{4}\varepsilon_0E_0^2$

$= \frac{1}{4}\times 8.85\times 10^{-12}(1)^2 = 2.2\times 10^{-12}\,J/m^3.$

48. (b) Area through which the energy of beam passes

$= (6.328\times 10^{-7}) = 4\times 10^{-13}\,m^2$

$\therefore\; I = \frac{P}{A} = \frac{10^{-3}}{4\times 10^{-13}} = 2.5\times 10^9\,W/m^2$

49. (a) $S_{av} = \frac{1}{2}\varepsilon_0 cE_0^2 = \frac{P}{4\pi R^2}$

$\Rightarrow E_0 = \sqrt{\frac{P}{2\pi R^2\varepsilon_0 C}}$

$= \sqrt{\frac{3}{2\times 3.14\times 100\times 8.85\times 10^{-12}\times 3\times 10^8}}$

= 1.34 V/m

50. (d) Intensity of EM wave is given by

$I = \frac{P}{4\pi R^2} = v_{av}.c = \frac{1}{2}\varepsilon_0E_0^2\times c$

$\Rightarrow E_0 = \sqrt{\frac{P}{2\pi R^2\varepsilon_0 c}}$

$= \sqrt{\frac{800}{2\times 3.14\times (4)^2\times 8.85\times 10^{-12}\times 3\times 10^8}}$

$= 54.77\ \frac{V}{m}$

51. (c) Wave impedance $Z = \sqrt{\frac{\mu_r}{\varepsilon_r}}\times\sqrt{\frac{\mu_0}{\varepsilon_0}}$

$= \sqrt{\frac{50}{2}}\times 376.6 = 1883\,\Omega$

52. (d) Momentum transferred in one second

$p = \frac{2U}{c} = \frac{2S_{av}A}{c} = \frac{2\times6\times40\times10^{-4}}{3\times10^{8}}$

$= 1.6\times10^{-10}$ *kg-m/s*^{2}.

53. (a) Specific rotation

$(\alpha) = \frac{\theta}{lc} \Rightarrow c = \frac{\theta}{\alpha l} = \frac{0.4}{0.01\times0.25} = 160\ kg/m^3$

Now percentage purity of sugar solution

$= \frac{160}{200}\times100 = 80\%$

54. (d) As $\theta \propto l$

Volume ratio 1 : 2 in a tube of length 30 *cm* means 10 *cm* length of first solution and 20 *cm* length of second solution .

Rotation produced by 10 *cm* length of first solution $\theta_1 = \frac{38°}{20}\times10 = 19°$

Rotation produced by 20*cm* length of second solution

$\theta_2 = -\frac{24°}{30}\times20 = -16°$

$\therefore$ Total rotation produced = 19° – 16° = 3°

55. (d) If I is the final intensity and I_0 is the initial intensity then

$I = \frac{I_0}{2}(\cos^2 30°)^5$ or $\frac{I}{I_0} = \frac{1}{2}\times\left(\frac{\sqrt{3}}{2}\right)^{10} = 0.12$

56. (a) Using Matus law, $I = I_0\cos^2\theta$

As here polariser is rotating *i.e.* all the values of θ are possible.

$I_{av} = \frac{1}{2\pi}\int_0^{2\pi} I\,d\theta = \frac{1}{2\pi}\int_0^{2\pi} I_0\cos^2\theta\,d\theta$

On integration we get $I_{av} = \frac{I_0}{2}$

where $I_0 = \frac{\text{Energy}}{\text{Area}\times\text{Time}} = \frac{p}{A} = \frac{10^{-3}}{3\times10^{-4}} = \frac{10}{3}\frac{Watt}{m^2}$

$\therefore\ I_{av} = \frac{1}{2}\times\frac{10}{3} = \frac{5}{3}\ Watt$

and Time period $T = \frac{2\pi}{\omega} = \frac{2\times3.14}{31.4} = \frac{1}{5}\ sec$

$\therefore$ Energy of light passing through the polariser per revolution $= I_{av}\times\text{Area}\times T$

$= \frac{5}{3}\times3\times10^{-4}\times\frac{1}{5} = 10^{-4}\ J.$

57. (d) Let *n*th minima of 400 *nm* coincides with *m*th minima of 560 *nm* then

$(2n-1)400 = (2m-1)560 \Rightarrow \frac{2n-1}{2m-1} = \frac{7}{5} = \frac{14}{10} = \frac{21}{15}$

i.e. 4th minima of 400 *nm* coincides with 3rd minima of 560 *nm*.

The location of this minima is

$= \frac{7(1000)(400\times10^{-6})}{2\times0.1} = 14\ mm$

Next, 11th minima of 400 *nm* will coincide with 8th minima of 560 *nm*

Location of this minima is

$= \frac{21(1000)(400\times10^{-6})}{2\times0.1} = 42\ mm$

$\therefore$ Required distance = 28 *mm*

58. (b) For maxima $\Delta = d\sin\theta = n\lambda$

$\Rightarrow 2\lambda\sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n}{2}$

since value of sin θ can not be greater 1.

$\therefore n = 0, 1, 2$

Therefore only five maximas can be obtained on both side of the screen.

59. (a) $\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow \frac{(401.8-393.3)}{393.3} = \frac{v}{3\times10^8}$

$\Rightarrow v = 6.48\times10^6\ m/s = 6480\ km/sec.$

60. (c) The interference fringes for two slits are hyperbolic.

61. (d) If you divide the original slit into N strips and represents the light from each strip, when it reaches the screen, by a phasor, then at the central maximum in the diffraction pattern you add N phasors, all in the same direction and each with the same amplitude. The intensity is therefore N^2. If you double the slit width, you need $2N$

phasors, if they are each to have the amplitude of the each to have the amplitude of the phasors you used for the narrow slit. The intensity at the central maximum is proportional to $(2N)^2$ and is, therefore, four times the intensity for the narrow slit.

62. (c) $I = 4I_0 \cos^2(\phi/2) \Rightarrow \phi = 2\pi/3$

$\Rightarrow \Delta x \times (2\pi/\lambda) = 2\pi/3 = \lambda/3$

$\sin\theta = \Delta x/d \Rightarrow \sin\theta = \lambda/3d$

63. (b) Momentum of the electron will increase. So the wavelength ($\lambda = h/p$)of electrons will decrease and fringe width decreases as $\beta \propto \lambda$.

Assertion and Reason

1. (d) When a light wave travel from a rarer to a denser medium it loses speed, but energy carried by the wave does not depend on its speed. Instead, it depends on the amplitude of wave.

2. (e) A narrow pulse is made of harmonic waves with a large range of wavelength. As speed of propagation is different for different wavelengths, the pulse cannot retain its shape while travelling through the medium.

3. (b) When d is negligibly small, fringe width β which is proportional to $1/d$ may become too large. Even a single fringe may occupy the whole screen. Hence the pattern cannot be detected.

4. (a) The central spot of Newton's rings is dark when the medium between plano convex lens and plane glass is rarer than the medium of lens and glass. The central spot is dark because the phase change of π is introduced between the rays reflected from surfaces of denser to rarer and rarer to denser media.

5. (a) For reflected system of the film, the maxima or constructive interference is $2\mu t\cos r = \frac{(2n-1)\lambda}{2}$ while the maxima for transmitted system of film is given by equation $2\mu t\cos r = n\lambda$

where t is thickness of the film and r is angle of reflection.

From these two equations we can see that condition for maxima in reflected system and transmitted system are just opposite.

6. (b) When intensity of light emerging from two slits is equal, the intensity at minima,

$I_{min} = \left(\sqrt{I_a} - \sqrt{I_b}\right)^2 = 0,$ or absolute dark.

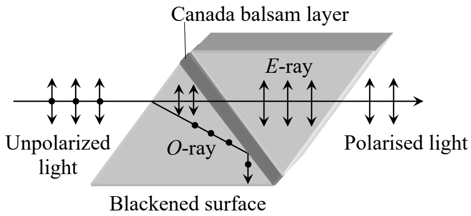
It provides a better contrast.

7. (c) When one of slits is covered with cellophane paper, the intensity of light emerging from the slit is decreased (because this medium is translucent). Now the two interfering beam have different intensities or amplitudes. Hence intensity at minima will not be zero and fringes will become indistinct.

8. (a) When a polaroid is rotated in the path of unpolarised light, the intensity of light transmitted from polaroid remains undiminished (because unpolarised light contains waves vibrating in all possible planes with equal probability). However, when the polaroid is rotated in path of plane polarised light, its intensity will vary from maximum (when the vibrations of the plane polarised light are parallel to the axis of the polaroid) to minimum (when the direction of the vibrations becomes perpendicular to the axis of the crystal). Thus using polaroid we can easily verify that whether the light is polarised or not.

9. (c) The nicol prism is made of calcite crystal. When light is passed through calcite crystal, it breaks up into two rays (i) the ordinary ray which has its electric vector perpendicular to the principal section of the crystal and (ii) the extra ordinary ray which has its electric vector parallel to the principal section. The nicol prism is made in such a way that it eliminates one of the two rays by total internal reflection, thus produces plane polarised light. It is generally found that the ordinary ray is

eliminated and only the extra ordinary ray is transmitted through the prism. The nicol prism consists of two calcite crystal cut at – 68° with its principal axis joined by a glue called Canada balsam.



10. (b) Doppler's effect is observed readily in sound wave due to larger wavelengths. The same is not the case with light due to shorter wavelength in every day life.

11. (d) In Young's experiments fringe width for dark and white fringes are same while in Young's double slit experiment when a white light as a source is used, the central fringe is white around which few coloured fringes are observed on either side.

12. (a) It is quite clear that the coloured spectrum is seen due to diffraction of white light on passing through fine slits made by fine threads in the muslin cloth.

13. (c) As the waves diffracted from the edges of circular obstacle, placed in the path of light interfere constructively at the centre of the shadow resulting in the formation of a bright spot.

14. (c) The beautiful colours are seen on account of interference of light reflected from the upper and the lower surfaces of the thin films.

15. (a) Microwave communication is preferred over optical communication because microwaves provide large number of channels and wider band width compared to optical signals as information carrying capacity is directly proportional to band width. So, wider the band width, greater the information carrying capacity.

16. (a)

17. (a) $\beta = \frac{\lambda D}{d}$

18. (c) The clouds consists of dust particles and water droplets. Their size is very large as compared to the wavelength of the incident light from the sun. So there is very little scattering of light. Hence the light which we receive through the clouds has all the colours of light. As a result of this, we receive almost white light. Therefore, the cloud are generally white.

19. (d) In sky wave propagation, the radio waves having frequency range 2 *MHz* to 30 *MHz* are reflected back by the ionosphere. Radio waves having frequency nearly greater than 30 *MHz* penetrates the inosphere and is not reflected back by the ionosphere. The TV signal having frequency greater than 30 *MHz* therefore cannot be propagated through sky wave propagation.

In case of sky wave propagation, critical frequency is defined as the highest frequency is returned to the earth by the considered layer of the ionosphere after having sent straight to it. Above this frequency, a wave will penetrate the inosphere and is not reflected by it.

20. (c) The television signals being of high frequency are not reflected by the ionosphere. So the T.V. signals are broadcasted by tall antenna to get large coverage, but for transmission over large distance satellites are needed. That is way, satellites are used for long distance T.V. transmission.

21. (e) We know, with increase in altitude, the atmospheric pressure decreases. The high energy particles (*i.e.* γ-rays and cosmic rays) coming from outer space and entering out earth's atmosphere cause ionisation of the atoms of the gases present there. The ionising power of these radiation decreases rapidly as they approach to earth, due to increase in number of collisions with the gas atoms. It is due to this reason the electrical conductivity of earth's atmosphere increase with altitude.

22. (a) In a radar, a beam signal is needed in particular direction which is possible if wavelength of wave is very small. Since the wavelength of microwaves is a few millimeter, hence they are used in radar.

23. (c) Hertz experimentally observed that the production of spark between the detector gap is maximum when it is placed parallel to source gap. This means that the electric vector of radiation produced by the source gap is parallel to the two gaps *i.e.,* in the direction perpendicular to the direction of propagation of the radiation.

24. (d) The atoms of the metallic container are set into forced vibrations by the microwaves. Hence, energy of the microwaves is not efficiently transferred to the metallic container. Hence food in metallic containers cannot be cooked in microwave oven. Normally in microwave oven the energy of waves is transferred to the kinetic energy of the molecules. This raises the temperature of any food.

25. (c) The earth's atmosphere is transparent to visible light and radio waves, but absorbs X-rays. Therefore X-rays telescope cannot be used on earth surface.

26. (b) Short wave (wavelength 30 *km* to 30 *cm*). These waves are used for radio transmission and for general communication purpose to a longer distance from ionosphere.

27. (b) The wavelength of these waves ranges between 4000 Å to 100 Å that is smaller wavelength and higher frequency. They are absorbed by atmosphere and convert oxygen into ozone. They cause skin diseases and they are harmful to eye and cause permanent blindness.

28. (d) Ozone layer in the stratosphere helps in protecting life of organism from ultraviolet radiation on earth. Ozone layer is depleted due to of several factors like use of chlorofluoro carbon (CFC) which is the cause of environmental damages.

29. (b) Radio waves can be polarised becomes they are transverse in nature. Sound waves in air are longitudinal in nature.

30. (a) In the absence of atmosphere, all the heat will escape from earth's surface which will make earth in hospitably cold.