Nature of light and interference of light

1. (d)

Diffraction shows the wave nature of light and photoelectric effect shows particle nature of light.

2. (d)

Huygen's theory explains propagation of wavefront.

3. (c)

When a beam of light is used to determine the position of an object, the maximum accuracy is achieved if the light is of shorter wavelength, because

$$\text{Accuracy} \propto \frac{1}{\text{Wavelength}}$$

4. Theory

5. (b)

In interference energy is redistribution.

6. (a)

For interference frequency must be same and phase difference must be constant.

7. Theory

8. Theory

9. (b)

$$\nu = \frac{c}{\lambda} = \frac{3 \times 10^8}{3000 \times 10^{-10}} = 10^{15} \; cycles/sec$$

10. (c)

$$\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\sqrt{\frac{I_1}{I_2}} - 1} \right)^2 \Rightarrow \frac{I_1}{I_2} = \frac{9}{4}$$

11. (d)

For destructive interference path difference is odd multiple of $\frac{\lambda}{2}$.

12. (c)

$$I_{max} = (\sqrt{I_1} + \sqrt{I_2})^2 = (\sqrt{I} + \sqrt{4I})^2 = 9I$$

$$I_{min} = (\sqrt{I_1} - \sqrt{I_2})^2 = (\sqrt{I} - \sqrt{4I})^2 = I$$

13. (d)

Laser beams are perfectly parallel. So that they are very narrow and can travel a long distance without spreading. This is the feature of laser while they are monochromatic and coherent these are characteristics only.

14. (a)

Photoelectric effect varifies particle nature of light. Reflection and refraction varifies both particle nature and wave nature of light.

15. $$n = \frac{c}{v} = \frac{\lambda_n}{\lambda_m}$$

$$\lambda_m = \frac{\lambda}{n}$$

16. (c)

Newton first law of motion states that every particle travels in a straight line with a constant velocity unless disturbed by an external force. So the corpuscles travels in straight lines.

17. (d)

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

For maximum I_R, $\phi = 0^o$

$\Rightarrow I_R = I_1 + I_2 + 2\sqrt{I_1 I_2} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

18. Theory

19. (c)

For constructive interference path difference is even multiple of $\frac{\lambda}{2}$.

20. (c)

For 2π phase difference $\rightarrow$ Path difference is λ

$\therefore$ For ϕ phase difference $\rightarrow$ Path difference is $\frac{\lambda}{2\pi}\times\phi$

Young's double slit experiment

21. d = 0.9 mm

D = 1 m

y = 1 mm

$$\frac{Yd}{D} = \frac{3\lambda}{2}$$

$$\frac{10^{-3}\times 9\times 10^{-4}}{1} = \frac{3\lambda}{2}$$

$$6\times 10^{-7} = \lambda$$

6000 Å or 600 nm

22. Theory

23. (a)

$\beta = \frac{\lambda D}{d}$; If λ and d both increase by 10%, there will be no change in fringe width (β).

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

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

$$\beta' = 4\beta$$

25. (d)

$n_1\lambda_1 = n_2\lambda_2 \Rightarrow 3\times 700 = 5\times\lambda_2 \Rightarrow \lambda_2 = 420\ nm$

26. (c)

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

$\beta_{air} = \frac{\lambda_{air} D}{d}$

$\beta_{water} = \frac{\lambda_{water} D}{d}$

$\frac{\beta_w}{\beta} = \frac{\lambda_w}{\lambda_a} = \frac{1}{n}$

$\beta_w = \frac{\beta}{n}$

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

If d will become $\frac{1}{3}^{rd}$ β will become 3 times.

28. $\Delta x = (\mu - 1)t$

29. (b)

$\beta \propto \lambda$

30. (a)

$$\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_1}{I_2}} + 1}{\sqrt{\frac{I_1}{I_2}} - 1}\right)^2 = \left(\frac{\sqrt{2} + 1}{\sqrt{2} - 1}\right)^2 \approx 34; \text{ (given } I_1 = 2I_2)$$

31. (d)

$\beta \propto \frac{\lambda}{d}$

32. (a)

When white light is used, central fringe will be white with red edges, and on either side of it, we shall get few coloured bands and then uniform illumination.

33. (d)

The refractive index of air is slightly more than 1. When chamber is evacuated, refractive index decreases and hence the wavelength increases and fringe width also increases.

34. (c)

For first minima $\theta = \frac{\lambda}{a}$ or $a = \frac{\lambda}{\theta}$

$\therefore a = \frac{6500 \times 10^{-8} \times 6}{\pi}$ (As $30^o = \frac{\pi}{6}$ radian)

$= 1.24 \times 10^{-4} cm = 1.24$ microns

35. (d)

Using relation, $d \sin\theta = n\lambda \Rightarrow \sin\theta = \frac{n\lambda}{d}$

For $n = 3$, $\sin\theta = \frac{3\lambda}{d} = \frac{3 \times 589 \times 10^{-9}}{0.589}$

$= 3 \times 10^{-6}$ or $\theta = \sin^{-1}(3 \times 10^{-6})$

36. (c)

$\beta \propto \lambda$

So β_v will be least.

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

if $d' = 2d$

then $D' = 2D$

for same fringe width.

38. Theory

39. (b)

$n_1\lambda_1 = n_2\lambda_2 \Rightarrow n_2 = n_1 \times \frac{\lambda_1}{\lambda_2} = 12 \times \frac{600}{400} = 18$

40. Shift = $\frac{D}{d}(\mu - 1)\,t$

41. (c)

Distance between consecutive bright fringes or dark fringes $= \beta$

$\beta = \frac{\lambda D}{d} = \frac{550 \times 10^{-9} \times 1}{1.1 \times 10^{-3}} = 500 \times 60^{-6} = 0.5\ mm$

42. $\beta = \frac{\lambda \times D}{d}$

43. (a)

In interference between waves of equal amplitudes *a,* the minimum intensity is zero and the maximum intensity is proportional to $4a^2$. For waves of unequal amplitudes *a* and *A*($A > a$), the minimum intensity is non zero and the maximum intensity is proportional to $(a + A)^2$, which is greater than $4a^2$.

44. (b, c)

For maxima, path difference $\Delta = n\lambda$

So for $n = 1$, $\Delta = \lambda = 6320\,Å$

45. (b)

Shift in the fringe pattern $x = \frac{(\mu - 1)t.D}{d}$

$= \frac{(1.5 - 1) \times 2.5 \times 10^{-5} \times 100 \times 10^{-2}}{0.5 \times 10^{-3}} = 2.5\ cm.$

46. (d)

If we use torch light in place of monochromatic light then overlapping of fringe pattern take place. Hence no fringe will appear.

47. Theory

48. Theory

49. Theory

50. Theory

51. (d)

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

$2\omega = \frac{\lambda D}{d}$

$4\omega = \frac{\lambda (2D)}{d}$

52. $\theta = \frac{\lambda}{d}$

$\frac{\theta_a}{\theta_\omega} = \frac{\lambda_a}{\lambda_\omega} = \frac{4}{3}$

$\theta_\omega = 0.75 \times 0.2 = 0.15^o$

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

$\frac{\lambda_1 D_1}{d_1} = \frac{\lambda_2 D_2}{d_2}$

$\frac{D_1}{d_2} = \left(\frac{d_1}{d_2}\right)\frac{\lambda_1}{\lambda_2}$

$= \left(\frac{2}{1}\right)\left(\frac{2}{1}\right) = 4:1$

54. Theory

55. D = 1.00 m

d = 1 mm

$0.06 \times 10^{-2} = \frac{\lambda \times 1}{10^{-3}}$

$\lambda = 6000 Å$

56. D = 20 cm

d = 0.1 mm

$\lambda = 5460 Å$

$\beta = \frac{\lambda D}{d} = \frac{5460 \times 10^{-10} \times 20 \times 10^{-2}}{0.1 \times 10^{-3}}$

= 1192×10^{-6} = 1.192 mm

57. Shift = $(\mu - 1)\frac{tD}{2d} = \left(\frac{2}{3}\right) \times \frac{tD}{2d}$

58. $\Delta x = \frac{\lambda}{2}$

59. $\Delta\phi = 2n\pi$

For n = 3

$\Delta\phi = 6\pi$

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

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

$\theta = \frac{6 \times 10^{-7}}{0.12 \times 10^{-3}} = 5 \times 10^{-3}$ rad

61. Theory

62. d = 0.2×10^{-3}

D = 2m

$\lambda = 5000 \times 10^{-10}$ m

$\beta = \frac{\lambda D}{d} = \frac{5 \times 10^{-7} \times 2}{2 \times 10^{-4}} = 5 \times 10^{-3}$

$3\beta = 15 \times 10^{-3}$ m = 1.5 cm

63. $\frac{3\beta}{2} = 10^{-3}$

$\frac{3}{2} \times \frac{\lambda \times 1}{9 \times 10^{-4}} = 10^{-3}$

$\lambda = \frac{18 \times 10^{-7}}{3}$ = 6×10^{-5} cm

64. Theory

65. (b)

$$\frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2}=\frac{9}{1}$$

$$\frac{\sqrt{I_1}+\sqrt{I_2}}{\sqrt{I_1}-\sqrt{I_2}}=3$$

$$2\sqrt{I_1}=4\sqrt{I_2}$$

$$\frac{\sqrt{I_1}}{\sqrt{I_2}}=2:1$$

66. (c)

$\frac{\beta_1}{\beta_2}=\frac{\lambda_1}{\lambda_2}$ or $\frac{1.0}{\beta_2}=\frac{5000}{6000}$ or $\beta_2=\frac{6000}{5000}=1.2\,mm$.

67. $\frac{\left(\sqrt{I_1}+\sqrt{I_2}\right)^2}{\left(\sqrt{I_1}-\sqrt{I_2}\right)^2}=\left(\frac{1+3}{1-3}\right)^2=4:1$

68. $\beta \propto \lambda$

69. $\beta \propto \frac{1}{d}$

70. $\beta \propto D$

Diffraction of light

71. Theory

72. (d)

Distance between the first dark fringes on either side of central maxima = width of central maxima

$=\frac{2\lambda D}{d}=\frac{2\times 600\times 10^{-9}\times 2}{1\times 10^{-3}}=2.4\,mm.$

73. Theory

74. (a)

The angular half width of the central maxima is given by $\sin\theta=\frac{\lambda}{a}\Rightarrow\theta=\frac{6328\times 10^{-10}}{0.2\times 10^{-3}}\,rad$

$=\frac{6328\times 10^{-10}\times 80}{0.2\times 10^{-3}\times\pi}\,degree=0.18^o$

Total width of central maxima $=2\theta=0.36^o$

75. $\beta \propto \lambda$

76. Angular width = $\frac{2\lambda}{d}$

77. (b)

Thickness of the film must be of the order of wavelength of light falling on film (*i.e.* visible light)

78. (a)

Using $d\sin\theta=n\lambda$, for $n=1$

$\sin\theta=\frac{\lambda}{d}=\frac{550\times 10^{-9}}{0.55\times 10^{-3}}=10^{-3}=0.001\,rad$

79. Theory

80. Theory

81. (d)

For n^{th} secondary maxima path difference

$d\sin\theta = (2n+1)\frac{\lambda}{2} \Rightarrow a\sin\theta = \frac{3\lambda}{2}$

82. (c)

Width of central maxima $= \frac{2\lambda D}{d}$

$= \frac{2\times 2.1\times 5\times 10^{-7}}{0.15\times 10^{-2}} = 1.4\times 10^{-3} m = 1.4\ mm$

83. Theory

84. (d)

The phase difference (ϕ) between the wavelets from the top edge and the bottom edge of the slit is $\phi = \frac{2\pi}{\lambda}(d\sin\theta)$ where d is the slit width. The first minima of the diffraction pattern occurs at $\sin\theta = \frac{\lambda}{d}$ so $\phi = \frac{2\pi}{\lambda}\left(d\times\frac{\lambda}{d}\right) = 2\pi$

85. Theory

86. (a)

For second dark fringe $d\sin\theta = 2\lambda$

$\Rightarrow\ 24\times 10^{-5}\times 10^{-2}\times \sin 30 = 2\lambda$

$\Rightarrow\ \lambda = 6\times 10^{-7} m = 6000\ Å$

87. (d)

Distance between the first dark fringes on either side of central maxima = width of central maxima $= \frac{2\lambda D}{d} =$ $\frac{2\times 600\times 10^{-9}\times 2}{1\times 10^{-3}} = 2.4\ mm.$

88. (c)

For the first minima $d\sin\theta = \lambda$

$\Rightarrow\ \sin\theta = \frac{\lambda}{d}\ \Rightarrow \theta = \sin^{-1}\left(\frac{5000\times 10^{-10}}{0.001\times 10^{-3}}\right) = 30^o$

89. Theory

Polarization of Light

90. (d)

$\mu = \tan\theta_P \Rightarrow \theta_P = \tan^{-1} n$

91. (c)

Polarisation is not shown by sound waves.

92. (d)

Ultrasonic waves are longitudinal waves.

93. (b)

$I = I_0\cos^2\theta = I_0\cos^2 45 = \frac{I_0}{2}$

94. Theory

95. (a)

It magnitude of light vector varies periodically during it's rotation, the tip of vector traces an ellipse and light is said to be elliptically polarised. This is not in nicol prism.

96. (c)

At polarizing angle, the reflected and refracted rays are mutually perpendicular to each other.

97. (a)

When unpolarised light is made incident at polarising angle, the reflected light is plane polarised in a direction perpendicular to the plane of incidence.

Therefore $\vec{E}$ in reflected light will vibrate in vertical plane with respect to plane of incidence.

Doppler's Effect of Light

98. (d)

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$, Now $\Delta\lambda = \frac{0.5}{100}\lambda \Rightarrow \frac{\Delta\lambda}{\lambda} = \frac{0.5}{100}$

$\therefore v = \frac{0.5}{100} \times c = \frac{0.5}{100} \times 3 \times 10^8 = 1.5 \times 10^6 m/s$

Increase in λ indicates that the star is receding.

99. (b)

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

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

100. (c)

Blue radiations have the wavelength around $4600\,\overset{o}{A}$. It shows that apparent wavelength is smaller than the real wavelength. It means that the star is proceeding towards earth.

101. (d)

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow v = \frac{\Delta\lambda}{\lambda}.c = \frac{5}{6563} \times (3 \times 10^8) = 2.29 \times 10^5$ *m/sec*

102. Theory

103. (d)

$\Delta\lambda = \frac{v}{c}\lambda = \frac{3600 \times 10^3}{3 \times 10^8} \times 5896 = 70.75 Å$

So the increased wavelength of light is observed.

104. (b)

Observed frequency $\nu' = \nu\left(1 - \frac{v}{c}\right)$

$\Rightarrow \nu' = 6 \times 10^{14}\left(1 - \frac{0.8\,c}{c}\right) = 1.2 \times 10^{14} Hz$

105. (a)

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow 1 = \frac{v}{c} \Rightarrow v = c$

106. Theory

107. (b)

Shifting towards ultraviolet region shows that Apparent wavelength decreased. Therefore the source is moving towards the earth.

Nature of light and interference of light

1. $\lambda' = \frac{\lambda}{\left(\frac{4}{3}\right)} = 3150\,Å$

2. Theory

3. Theory

4. Theory

5. Theory

6. Theory

7. (c)

$$\frac{I_{max}}{I_{min}} = \left(\frac{\frac{a_1}{a_2}+1}{\frac{a_1}{a_2}-1}\right)^2 = \left(\frac{\frac{4}{3}+1}{\frac{4}{3}-1}\right)^2 = \frac{49}{1}$$

8. (d)

Intensity $\propto \frac{1}{(\text{Distance})^2}$

9. (a)

Phenomenon of interference of light takes place.

10. Theory

11. Theory

12. (a)

In the normal adjustment of young's, double slit experiment, path difference between the waves at central location is always zero, so maxima is obtained at central position.

13. (d)

$\beta = \frac{\lambda D}{d} \Rightarrow$ If D becomes twice and d becomes half so β becomes four times.

14. Theory

15. Theory

16. (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 $4I$. At C it is zero and at B, the phase difference is 90°, so intensity is $2I$.

17. Theory

18. (c)

According to Plank's hypothesis, black bodies emits radiations in the form of photons.

19. Theory

20. $\mathrm{I_0} = \left(\sqrt{\mathrm{I}} + \sqrt{\mathrm{I}}\right)^2$

Young's double slit experiment

21. (d)

$I = a_1^2 + a_2^2 + 2a_1a_2 \cos\phi$

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

22. $\Delta x = \frac{\lambda}{2}$

$$\frac{d}{\cos\theta} + \frac{d\cos 2\theta}{\cos\theta} = \frac{\lambda}{2}$$

$$\cos\theta = \frac{\lambda}{4d}$$

23. (d)

If shift is equivalent to n fringes then

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

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

24. (a)

According to given condition

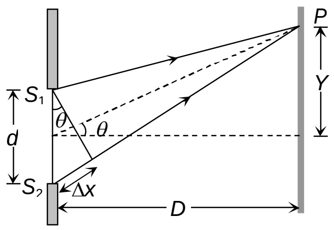
$(\mu-1)t = n\lambda$ for minimum t, $n = 1$

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

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

25. (a,b)

For microwave $\lambda = \frac{c}{f} = \frac{3\times10^8}{10^6} = 300\, m$



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

Phase difference $\phi = \frac{2\pi}{\lambda}(\text{Path difference}) = \frac{2\pi}{\lambda}(d\sin\theta) = \frac{2\pi}{300}(150\sin\theta) = \pi\sin\theta$

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

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

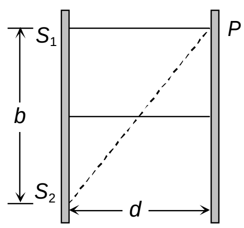
If $\theta = 0$, then $I = I_o\cos\theta = I_o$

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

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

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

27. (a)

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

$\Rightarrow \frac{\beta_1}{\beta_2}=\frac{D_1}{D_2}\Rightarrow \frac{\beta_1-\beta_2}{\beta_2}=\frac{D_1-D_2}{D_2}\Rightarrow \frac{\Delta\beta}{\Delta D}=\frac{\beta_2}{D_2}=\frac{\lambda_2}{d_2}=\lambda_2=\frac{3\times10^{-5}}{5\times10^{-2}}\times10^{-3}=6\times10^{-7}m=6000Å$

28. (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 $P = S_1B = 10\lambda = 10\times6000\times10^{-10} = 6\times10^{-6}m$.

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

30. Theory

31. (a, d)

These waves are of same frequencies and they are coherent

32. (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 $y = 4cm$.

33. (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

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

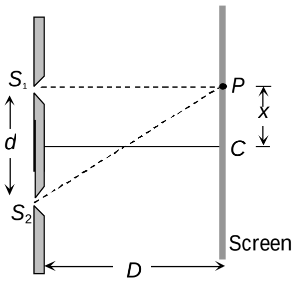
Hence corresponding phase difference

$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \frac{\pi}{2}$

Resultant intensity at P

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

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



34. (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.

35. (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.

36. $\frac{11}{2}\beta = 10\beta'$

$n = \frac{20}{11}$

37. $\varphi_0 = \left(\frac{2\pi}{\lambda}\right)x$

$\lambda = \frac{\lambda_0}{n}$

38. (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 $= \frac{n\lambda_1 D}{d} = \frac{5 \times 900 \times 10^{-9} \times 2}{2 \times 10^{-3}} = 45 \times 10^{-4} m = 4.5\,mm$

39. shift is equal to β

40. $3\beta_1 = 4\beta_2$

$3\lambda_1 = 4\lambda_2$

41. (c)

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

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

42. (a)

In interference between waves of equal amplitudes *a,* the minimum intensity is zero and the maximum intensity is proportional to $4a^2$. For waves of unequal amplitudes *a* and $A(A > a)$, the minimum intensity is non zero and the maximum intensity is proportional to $(a + A)^2$, which is greater than $4a^2$.

43. $(n+1)\beta_B = n\beta_R$

44. $\frac{d}{2} = \frac{9}{2}\beta$

45. $\Delta x = \frac{d}{2} = \frac{n\lambda}{2}$

Destructive interference.

46. $\Delta x = \frac{\lambda}{2}$

$\frac{d^2}{D} = \frac{\lambda}{2}$

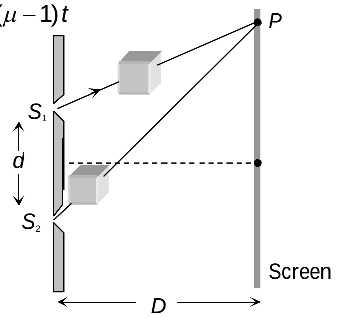
$d = \sqrt{\frac{\lambda D}{2}}$

47. $\lambda = \frac{\lambda}{\sqrt{2meV}}$

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

48. (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 $5\beta = \frac{\beta}{\lambda}(\mu_1 - \mu_2)t \Rightarrow t = \frac{5\lambda}{(\mu_2 - \mu_1)} = \frac{5 \times 4800 \times 10^{-10}}{(1.7 - 1.4)} = 8 \times 10^{-6} m = 8\mu m.$

49. (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 $(XO) = \lambda(n + l)$

50. Theory

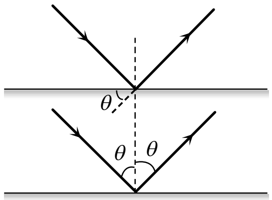
51. (c)

Path difference $= 2d\sin\theta$

$\therefore$ For constructive interference

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

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



52. $\frac{yd}{D_1} + \frac{(\text{shift})d}{D_2} = 0$

53. $d\sin\theta = \frac{\lambda}{2}$

54. $I = I_0\cos^2\left(\frac{\theta}{2}\right) = \frac{2\pi x}{\beta}$

55. $\frac{2\lambda D}{d} = \frac{10\lambda D}{1mm}$

Diffraction of light

56. Theory

57. Theory

58. Theory

59. $d\sin\theta = \lambda$

60. Theory

61. Theory

62. (c)

Position of first minima = position of third maxima *i.e.*, $\frac{1\times\lambda_1 D}{d} = \frac{(2\times 3+1)}{2}\frac{\lambda_2 D}{d} \Rightarrow \lambda_1 = 3.5\lambda_2$

63. Theory

64. (a)

Position of n[th] minima $x_n = \frac{n\lambda D}{d}$

$\Rightarrow 5\times10^{-3} = \frac{1\times 5000\times10^{-10}\times1}{d}$

$\Rightarrow d = 10^{-4}\ m = 0.1\ mm$.

65. $\frac{dy}{D} = \lambda$

y = 0.8 mm,

d = 0.3 mm

D = 40 cm

66. Theory

Polarization of Light

67. (d)

In the arrangement shown, the unpolarised light is incident at polarising angle of 90° – 33° = 57°. The reflected light is thus plane polarised light. When plane polarised light is passed through Nicol prism (a polariser or analyser), the intensity gradually reduces to zero and finally increases.

68. Theory

69. Theory

A plane which contains $\vec{E}$ and the propagation direction is called the plane of polarization.

70. Theory

71. (d)

Light suffers double refraction through calcite.

72. Theory

73. Theory

74. Theory

75. Theory

76. Theory

Doppler's Effect of Light

77. (b)

78. (d)

$\Delta\lambda = \frac{v_s}{c}\lambda \Rightarrow v_s = \frac{\Delta\lambda . c}{\lambda} = \frac{47\times3\times10^8}{4700} = 3\times10^6 m/s$ away from earth

79. (b)

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow \frac{0.05}{100} = \frac{v}{3\times10^8} \Rightarrow v = 1.5\times10^5\ m/s$

(Since wavelength is decreasing, so star coming closer)

80. (c)

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \therefore v = \frac{\Delta\lambda}{\lambda}c = \frac{0.1}{6000}\times3\times10^5 km/s = 5\ km/s$

81. (b)

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow \Delta\lambda = \frac{5700\times10^6}{3\times10^3} = 19\mathring{A}$

82. (b)

$\nu' = \nu\left(1-\frac{v}{c}\right) = 4\times10^7\left(1-\frac{0.2c}{c}\right) = 3.2\times10^7 Hz$

83. (b)

Observed frequency $\nu' = \nu\left(1-\frac{v}{c}\right)$

$\Rightarrow \nu' = 6\times10^{14}\left(1-\frac{0.8\ c}{c}\right) = 1.2\times10^{14} Hz$

84. Theory

85. (a)

$\Delta\lambda = \lambda\frac{v}{c}$ and $v = r\omega$

$v = 7\times10^8\times\frac{2\pi}{25\times24\times3600}, c = 3\times10^8 m/s$

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

86. (d)

$\frac{\Delta\lambda}{\lambda} = \frac{v}{c} \Rightarrow v = \frac{c}{\lambda}\Delta\lambda = \frac{c}{\lambda}(\lambda'-\lambda) = c\times\frac{0.01}{100} = 3\times10^4 m/s = 30\ km/\sec$

ASSERTION & 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)

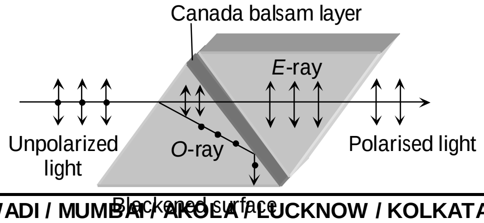
When one of slits is covered with cellophane paper, the intensity of light emerging from the slit is decreased (because this medium is translucent). Now the two interfering beam have different intensities or amplitudes. Hence intensity at minima will not be zero and fringes will become indistinct.

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.

PREVIOUS YEAR ASKED QUESTIONS IN 2012

1. $\beta \propto \lambda$

$$\beta' = \frac{\beta}{n}$$

2. $I = I_0 \cos^2\theta = \frac{I_0}{4}$

3. Theory

4. $\frac{3\beta}{2} = 1\text{mm}$

$$\frac{3}{2} \times \frac{\lambda D}{d} = 10^{-3}$$

$$\frac{3}{2} \times \frac{\lambda \times 1}{0.9 \times 10^{-3}} = 10^{-3}$$

$$\lambda = \frac{2}{3} \times 9 \times 10^{-7}$$

$$\lambda = 6 \times 10^{-7}\,\text{m}$$

5. Theory

REFRACTION OF LIGHT AT PLANE SURFACE

1. On the wavefront, all the points are in same phases.

2. $A = \sqrt{A_1^2 + A_2^2 + 2A_1A_2 \cos\theta}$

$I = 9A^2 + 4A^2 + 2 \times 3A \times 2A \times \frac{1}{2}$

$I = 19A^2$

3. Given, λ = 6000Å= 6000 × 10^{-1}

and n = 0.3 mm = 0.3 × 10^{-3} m

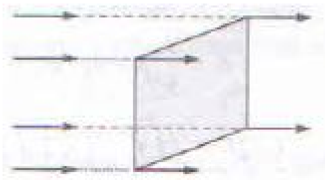
$0.3 \times 10^{-3} \times \sin\theta = 6000 \times 10^{-10}$

$\sin\theta = 2 \times 10^{-3} = 2 \times 10^{-3}$ rad

9. The wave theory cannot explain the phenomena of Compton effect and Photoelectric effect.

10. Photoelectric effect stales that light travels in the form of bundles or packets of energy, called photons. This effect is explained on the basis of quantum nature of light. So. It clearly explains the particle's nature of light.

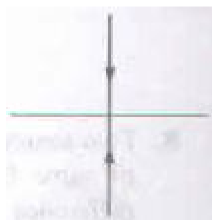
11. When the point source or linear source of light is at very large distance, a small portion of spherical or cylindrical wavefront appears to be plane, such a wavefront is called a plane wavefront.



In the given options none of sources generates plane wavefront, it can be artificially produced by reflection from 2 mirror or by refraction through a lens.

12. As velocity of light is perpendicular to the wavefront and light is travelling in vacuum along the v-axis. therefore, the wavefront is represented by y - constant.

14. From Huygen's principle, if the incident wavefront be parallel to the interface of the two media (i = 0), then the refracted wavefront will also be parallel to the interface of (r = 0). In other words, if light rays fall normally on the interface, then on passing to the second medium they will not deviate from their original path.



INTERFERENCE OF LIGHT

1. All the wavelength arc scattered nearly equally, a >> λ.

2. If two sources have a randomly varying phase difference ϕ the resultant intensity will be $\frac{I_0}{\sqrt{2}}$

3. In this case, the Fresnel distance is equivalent to a/λ .

4. Phase difference $\phi = \frac{2\pi}{\lambda} \times$ Path difference.

$= \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{\pi}{3} = 60^0$

Intensity, $I = I_0 \cos^2\left(\frac{\phi}{2}\right)$

$$\frac{I}{I_0} = \cos^2(30^o) = \left(\frac{\sqrt{3}}{2}\right)^2 = 0.75$$

5. Condition for constructive interference is

$$2\mu t = [2n+1]\frac{\lambda}{2}$$

Where, n = 0, 1, 2, 3.

For minimum thickness, n = 0

$$2\mu t = \frac{\lambda}{2} \qquad \Rightarrow \qquad t = \frac{\lambda}{4\mu} = \frac{600\times10^{-9}}{4\times1.5} = 100 \text{ nm}$$

6. $$\frac{I_{max}}{I_{min}} = \left(\frac{a_1+a_2}{a_1-a_2}\right)$$

$$\frac{a_1+a_2}{a_1-a_2} = \sqrt{\frac{36}{1}}$$

$$\frac{a_1+a_2}{a_1-a_2} = 6$$

$$a_1 + a_2 = 6a_1 - 6a_2$$

$$7a_2 = 5a_1$$

$$\frac{a_1}{a_2} = \frac{7}{5}$$

$\Rightarrow$ $a_1 : a_2 = 7 : 5$

7. $$\frac{I_{max}}{I_{min}} = \frac{(\sqrt{2I}+\sqrt{I})^2}{(\sqrt{2I}-\sqrt{I})^2} = \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2 = \left[\frac{(\sqrt{2}+1)(\sqrt{2}+1)}{(\sqrt{2}-1)(\sqrt{2}+1)}\right]^2 = \left(\frac{2+1+2\sqrt{2}}{2-1}\right)^2 = \frac{9+8+12\sqrt{2}}{1} \approx 34$$

8. Two sources arc said to be coherent, if they emit light waves of same frequency or wavelength and of a stable phase difference i.e. $\phi(x)$ = constant.

9. Given, $I_1 = I,\ I_2 = 4I$

$$I_{max} = (\sqrt{I_1}+\sqrt{I_2})^2 = (\sqrt{I}+\sqrt{4I})^2 = (3\sqrt{I})^2 = 9I$$

$$I_{min} = (\sqrt{I_1}-\sqrt{I_2})^2 = (\sqrt{I}-\sqrt{4I})^2 = (-\sqrt{I})^2 = I$$

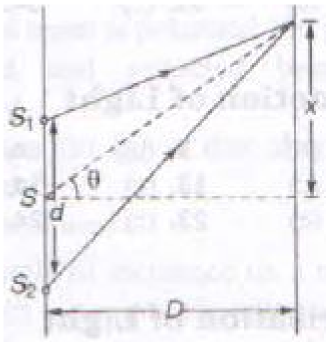
10. Fringe width, $\beta = \frac{D\lambda}{d}$ or $\beta \propto \lambda$

If the experiment is performed in water, wavelength λ decreases, so, fringe width also decreases.

11. Let λ be wavelength of monochromatic light incident on slit S, then angular distance between two consecutive fringes, that is the angular fringe width is

$$\theta = \frac{\lambda}{d} \qquad \text{(i)}$$

where, d is distance between coherent sources.



Given, $\frac{\Delta\theta}{\theta} = \frac{10}{100}$

So, from eq. (i)

$\frac{\Delta\lambda}{\lambda} = \frac{\Delta\theta}{\theta} = \frac{10}{100} = 0.1$

$\Rightarrow$ $\Delta\lambda = 0.1\lambda = 0.1 \times 5890Å = 589Å$ (increases)

12. Distance of nth maximum, $x = n\lambda\frac{D}{d} \propto \lambda$

As, $\lambda_b < \lambda_g$

$\therefore$ $x_{blue} < x_{green}$

13. $\lambda_1 = 6000Å$, n_1 = 16 fringes

$\therefore$ n_2 = 24 fringes

$v = n\lambda$

$\Rightarrow$ $\frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$

$\Rightarrow$ $\frac{6000}{\lambda_2} = \frac{24}{16}$

$\Rightarrow$ $\lambda_2 = \frac{6000 \times 16}{24} = \frac{96000}{24} = 4000Å$

14. Position of nth bright fringe from central maximum is $\frac{n\lambda D}{d}$

$\therefore$ $\frac{8\lambda_1 D}{d} = \frac{9\lambda_2 D}{d}$

$\frac{\lambda_1}{\lambda_2} = \frac{9}{8}$

Which is correct only option (d)

15. Resultant intensity of two periodic waves is given by

$I = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\delta$

Where δ is the phase difference between the waves

For maximum intensity, $\delta = 2n\pi$, n = 0, 1, 2,…… etc.

16. Therefore, for zero order maxima, $\cos\delta = 1$

$I_{max} = I_1 + I_2 + 2\sqrt{I_1 I_2} = (\sqrt{I_1} + \sqrt{I_2})^2$

For minimum intensity, $\delta = (2n-1)\pi$, n = 1, 2, ….. etc.

Therefore, for 1^{st} order minima,

$\cos\delta = -1$

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

Therefore, $I_{max} + I_{min} = (\sqrt{I_1} + \sqrt{I_2})^2 + (\sqrt{I_1} - \sqrt{I_2})^2$

$= 2(I_1 + I_2)$

16. Fringe width $\beta = \frac{\lambda D}{d} = \frac{600 \times 10^{-9} \times 2}{1 \times 10^{-3}} = 12 \times 10^{-4}\,m$

So, distance between the first dark fringes on either side of the central bright fringe

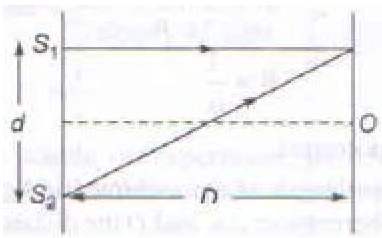
$X = 2\beta$

$= 2 \times 12 \times 10^{-4}\,m = 24 \times 10^{-4}\,m = 2.4\ mm$

17. The rings observed in reflected light are exactly complementary to those seen in transmitted light. Corresponding to very dark ring in reflected light there is a bright ring in transmitted light. The ray reflected at the upper surface of the air-film suffers no phase change while the ray reflected internally at the lower surface suffers a phase change of π

18. When dark fringe is obtained at the point opposite to one of the slits then

$S_1P = D$ and $S_2P = \sqrt{D^2 + d^2}$



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

Path difference = $S_2P - S_1P$

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

$= \frac{d^2}{2D} = \frac{\lambda}{2}$ or $\lambda = \frac{d^2}{D}$

$\Rightarrow \lambda \propto d^2$

Now, intensity of a dark fringe is zero.

19. Intensity at the centre of bright fringe,

$I_0 = I + I + 2\sqrt{II}\cos 0^o$

$I_0 = 2I + 2I$

$I_0 = 4I$

Intensity at a point distant $\frac{\beta}{4}$

(with a phase difference = $\frac{2\pi}{4} = \frac{\pi}{2}$) is

$I' = I + I + \sqrt{II}\cos\frac{\pi}{2}$

$I' = 2I \qquad \left[\because \quad \cos\frac{\pi}{2} = 0\right]$

$\therefore \quad \frac{I_0}{I} = \frac{4I}{2I} = 2$

20. The film appears bright if the path difference is $2\mu r\cos r = (2n-1)\frac{\lambda}{2}$ n = 1, 2, 3, …..

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

$\lambda = \frac{4\times1.4\times10000\times10^{-10}\cos 0^{o}}{(2n-1)} = \frac{56000}{(2n-1)}\text{Å}$

$\therefore \quad \lambda = 56000\text{Å}, 18666\text{Å}, 11200\text{Å}, 8000\text{Å}, 6222\text{Å}, 5091\text{Å}, 4308\text{Å}, 3733\text{Å}$

The wavelengths which are not within specified ranges are to be rejected.

21. Two sources should have the same wavelength, nearly the same amplitude and have a constant phase difference. If the phase difference between two interfering waves docs not remain constant, interference pattern will not be sustained.

22. In an interference experiment the spacing between successive maxima and minima is called the fringe width and is given by

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

23. Given that the distance between two slits

$d' = \frac{d}{2}$

and the distance between screen and slit

$D' = 3D$

We know the fringe width

$\beta = \frac{D\lambda}{d} \qquad$ (i)

According to question

$\Rightarrow \quad \beta' = \frac{D'\lambda}{d'}$

$\beta' = \frac{3D.\lambda}{d/2}$

$\beta' = 6\frac{D\lambda}{d}$ (ii)

On dividing eq. (ii) by eq. (i)

$$\frac{\beta'}{\beta} = \frac{\frac{6D\lambda}{d}}{\frac{D\lambda}{d}}$$

$$\Rightarrow \frac{\beta'}{\beta} = 6$$

$$\Rightarrow \beta' = 6\beta$$

Hence, the width of the fringe becomes 6 times.

24. Distance of nth dark fringe from central fringe

$$x_n = \frac{(2n-1)\lambda D}{2d}$$

$$\therefore \quad x_2 = \frac{(2\times -1)\lambda D}{2d} = \frac{3\lambda D}{2d}$$

$$\Rightarrow 1\times 10^{-3} = \frac{3\lambda \times 1}{2\times 0.9\times 10^{-3}} \Rightarrow \text{cm}$$

25. For possible interference maxima on the screen, the condition is

$d\sin\theta = n\lambda$ (i)

Given, d = slit-width = 2λ

$\therefore \quad 2\lambda\sin\theta = n\lambda \Rightarrow \quad 2\sin\theta = n$

The maximum value of $\sin\theta$ is 1, hence

$n = 2\times 1 = 2$

Thus, eq.(i) must be satisfied by 5 integer values i.e., –2, –1, 0, 1, 2. Hence, the maximum number of possible interference maxima is 5.

26. When the light rays fall on thin film of oil then rays are reflected from upper and lower layer of the thin films. These reflected rays produce interference pattern due to which surface of thin film appears as coloured.

27. If a transparent medium of thickness t and refractive index μ is introduced in the path of one of the slits, then effective path in air is increased by an amount $(\mu-1)t$ due to introduction of plate. Therefore, the zeroth fringe shifts to a new position where the two optical paths arc equal. In such case fringe width remains unchanged.

The central fringe is bright or dark depends upon the initial phase difference between the two coherent sources.

28. When a thin film of oil spreads over the surface of water, and observed in broad day light, then brilliant colours are observed. These colours arise due to interference of sunlight reflected from lower and upper surface of the film.

If thickness of film at a point is such that optical path difference $\delta = 0, \lambda, 2\lambda, 3\lambda....$ then the film appears dark and if $\delta = \frac{\lambda}{2}, \frac{3\lambda}{2}, \frac{5\lambda}{2}, ...$ film will appear bright.

Hence, colours of soap film change because of thickness of film.

29. Suppose slit width's are equal so they produces waves of equal intensity say I'. Resultant intensity at any point $I_R = 4I'\cos^2\phi$ where ϕ is the phase difference between the waves at the point of observation.

For maximum intensity, $\phi = 0^o$

$\Rightarrow\ I_{max} = 4I' = I$ (i)

If one of slit is closed, resultant intensity at the same point be

I' only i.e., $I' = I_0$

Comparing eqs. (i) and (ii) we get

$I = 4I_0$

30. The rays of light from two coherent sources superimpose each other on the screen forming alternate maxima (with maximum intensity I_0) and minima (with intensity zero). If two non-coherent sources superimpose, there will be no maxima and minima, instead the intensity will be $\frac{I_0}{2}$ throughout.

31. In Young's double slit experiment half angular width is given

$$\sin\theta = \frac{\lambda}{d}$$

$$\sin\theta = \frac{589\times10^{-9}}{0.589\times10^{-3}} = 10^{-3}$$

$$\Rightarrow\ \theta = \sin^{-1}(0.001)$$

32. The fringe width obtained in a two slit experiment is given by

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

or $\beta \propto \lambda$

$\therefore\ \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$ or $\frac{1.0}{\beta_2} = \frac{5000}{6000}$ or $\beta_2 = \frac{6000}{5000}$ =1.2 mm

33. Fringe width

$\beta = \frac{D\lambda}{d}$ (i)

and $\lambda \propto \frac{1}{\mu}$ (ii)

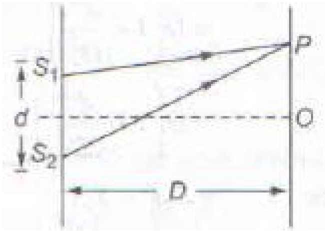
From Eqs. (i) and (ii)

$$\beta \propto \lambda \propto \frac{1}{\mu}$$

$$\therefore\ \beta \propto \frac{1}{\mu}$$

Hence (a) is correct.

34. Let λ be wavelength of monochromatic light, d the distance between coherent sources, and D the distance between screen and source, then fringe width is



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

Given, $d' = 10d$, $D' = \frac{D}{2}$

$$\therefore \quad \beta' = \frac{\frac{D}{2}\lambda}{10d} = \frac{D\lambda}{20d}$$

$$\Rightarrow \beta' = \frac{\beta}{20}$$

35. The position of 30th bright fringe

$$y_{30} = \frac{30\lambda D}{d}$$

Now, position shift to central fringe is

$$y_0 = \frac{30\lambda D}{d}$$

But we know $y_0 = \frac{D}{d}(\mu - 1)\,t$

$$\frac{30\lambda D}{d} = \frac{D}{d}(\mu - 1)\,t$$

$$(\mu - 1) = \frac{30\lambda}{t} = \frac{30 \times 6000 \times 10^{-10}}{3.6 \times 10^{-5}} = 0.5$$

$$\mu = 1.5$$

36. Angular fringe width of first minima

$$\frac{2x}{D} = 2(2n-1)\frac{\lambda}{2d} = (2n-1)\frac{\lambda}{d}$$

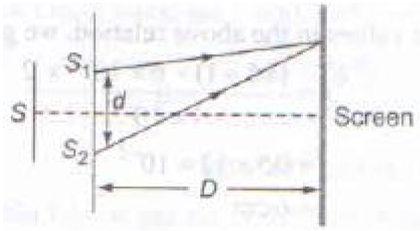
Given, d = 0.6 mm = 0.6×10^{-3} m

$\lambda = 4800 Å = 4.8 \times 10^{-7}$ m, n = 1

$$\therefore \quad \frac{2x}{D} = \frac{(2 \times 1 - 1) \times 4.8 \times 10^{-7}}{0.6 \times 10^{-3}} = 8 \times 10^{-4}\,\text{rad}$$

37. Coherent time = $\frac{\text{Coherence length}}{\text{Velocity of light}} = \frac{L}{c}$

38. In Young's double slit experiment, let screen is placed at a distance D, d is the distance between coherent sources.



The fringe width is given by

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

where, λ is wavelength of light used.

When dipped in water, wavelength is $\lambda_w = \frac{\lambda_a}{\mu}$, hence, it decreases.

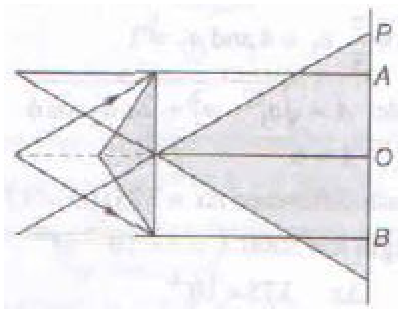
Therefore, fringe width decreases and he*™, fringe pattern shrinks.

39. $I_1 = I_2 = 1\,Wm^{-2}$

So, resultant intensity at third vertex

$$I = (\sqrt{I_1} + \sqrt{I_2})^2 = (\sqrt{1} + \sqrt{1})^2 = (1+1)^2 = 4\,Wm^{-1}$$

40. Fresnel used a biprism to obtain two coherent sources for producing interference fringes in the laboratory. It consists of two acute angled prisms with their bases in contact. In actual practice, the biprism is constructed as a single prisms of obtuse angle of about 179° and the remaining two acute angles are $3'$ each. In biprism, the virtual images act as two coherent superimposed and interference fringes are formed in overlapping region AH on a screen placed at O.



In order to measure the distance d between the virtual sources S_1 and S_2. Glazebrook gave a method, known as magnification method due to Glazebrook. If d_1 and d_2 are distance between real images of S_1, and S_2, then

$$d = \sqrt{d_1 d_2}$$

Given, d_1 = 16 cm, d_2 = 9 cm

$\therefore \quad d = \sqrt{16 \times 9}$ = 12 cm

41. Given $\lambda_1 = 5893\,Å$, $n_1 = 62$, $\lambda = 4358\,Å$

As field of view in case of both the wavelengths is same, hence

as $n_1\left(\frac{D\lambda_1}{d}\right) = n_2\left(\frac{D\lambda_2}{d}\right)$ or $n_2 = n_1\left(\frac{\lambda_1}{\lambda_2}\right) = 62 \times \frac{5893}{4358} = 84$

42. In interference pattern

Fringe width $= \frac{\lambda D}{d} = w$ ($\because$ given)

According to the condition

$$w' = \frac{\lambda \times 2D}{\frac{d}{2}} = 4 \times \frac{\lambda D}{d} = 4w$$

43. When white light is used in Young's double slit experiment, then different colours will be split up on the viewing screen according to their wavelength while the central fringe will be white.

44. When rays of monochromatic light of wavelength λ are incident on a diffraction grating in which slit separation is d, then for angle of diffraction θ, the following relation holds true.

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

Where n is called the spectrum order.

Given, n = 1, $\lambda = 6500\,\text{Å} = 6500 \times 10^{-10}\text{m}$ and $\sin 30^{o} = \frac{1}{2}$

$$\Rightarrow \quad d = \frac{n\lambda}{\sin 30^{o}}$$

$$\therefore \quad d = \frac{6500 \times 10^{-10}}{(1/2)}$$

$$d = 1.3 \times 10^{-6}\text{m}$$

45. Given, $\phi = \frac{\pi}{3}$, $a_1 = 4$ and $a_2 = 3$

Amplitude $A = \sqrt{a_1^2 + a_2^2 + 2a_1a_2\cos\phi}$

$\Rightarrow$ A = 6

46. Given, path difference $\Delta x = 3.75\mu m = 3.75 \times 10^{-6}\,m$ and

Wavelength $\lambda = 5000\text{Å} = 5 \times 10^{-7}\,m$

$$\frac{\Delta x}{\lambda} = \frac{3.75 \times 10^{-6}}{5 \times 10^{-7}} = \frac{37.5}{5} = 7.5$$

$$\therefore \quad \Delta x = 7.5\lambda$$

Hence, Δx is odd multiple of λ, so point is dark.

47. The optical path between any two points is proportional to the time of travel.

The distance traversed by light in a medium of refractive index μ in time t is given by

d = vt (i)

where v is velocity of light in the medium. The distance traversed by light in a vacuum in this time, $\Delta = ct$

$= c.\frac{d}{v}$ [From Eq. (i)]

$= d\frac{c}{v} = \mu d$ (ii)

$\left(\text{Since, } \mu = \frac{c}{v}\right)$

This distance is the equivalent distance in vacuum called optical path.

Here, optical path for first ray = n_1L_1

Optical path for second ray = n_2L_2

Path difference = $n_1L_1 - n_2L_2$

Now, phase difference = $\frac{2\pi}{\lambda} \times \text{path difference} = \frac{2\pi}{\lambda} \times (n_1L_1 - n_2L_2)$

48. We know, that $I \propto a^2$ or $a \propto \sqrt{I}$

$\therefore \frac{a_1}{a_2} = \sqrt{\left(\frac{I_1}{I_2}\right)}$

So, $\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(a_1 + a_2)^2}{(a_2 - a_1)^2} = \frac{(1+\sqrt{\beta})^2}{(1-\sqrt{\beta})^2}$

Applying componendo and dividend

$\frac{I_{max} + I_{min}}{I_{max} - I_{min}} = \frac{(1+\sqrt{\beta})^2 + (1-\sqrt{\beta})^2}{(1+\sqrt{\beta})^2 - (1-\sqrt{\beta})^2} = \frac{2+2\beta}{4\sqrt{\beta}}$ or $\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{2\sqrt{\beta}}{1+\beta}$

49. Distance between two adjacent bright (or dark) fringe called the fringe width. It is denoted by β, thus.

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

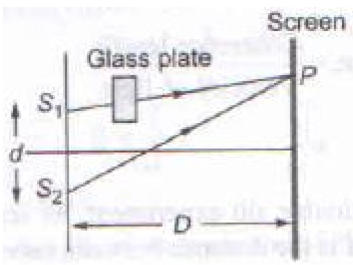
where D is the distance between slit source and screen and d is separation of slits.

Since, D and d are increased to same extent, so fringe width (β) will remain unchanged.

50. When a thin glass plate of thickness t is placed over one of the slits, then lateral displacement is given by

$x = \frac{(\mu - 1)\, tD}{d}$

Given, $\mu = 1.5$, $t = 0.06\,\text{mm} = 6 \times 10^{-5}\,\text{m}$ and D = 2m, d = 1mm = $1 \times 10^{-3}\,\text{m}$

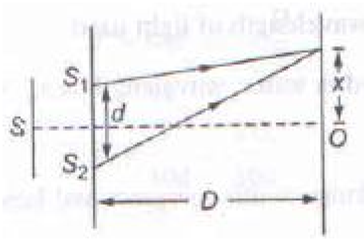


Putting the values in the above relation, we get

$x = \frac{(1.5-1) \times 6 \times 10^{-5} \times 2}{1 \times 10^{-3}} = 0.5 \times 12 \times 10^{-2} = 6\text{ cm}$

51. In Young's double slit experiment, for maximum intensity (bright fringe)

$$x = m\frac{D\lambda}{d}$$



where m is path difference, D the distance between screen and coherent sources, d the distance between coherent sources and λ the wavelength.

Putting m = 0, we get the position of the central bright fringe (which is called zero order fringe). Hence , at point O the path difference between two wavelets is zero. Hence, at O there is always a bright fringe. This is called the central fringe.

54. On placing the thin film of mica in the path of one of the interfering beam in the interference experiment, the path difference of the beam changes. On account of this, the fringe pattern shifts upwards. The width of fringe is not affected at all.

55. In Young's double slit experiment if distance between coherent source is d, and distance between screen and source is D, then fringe width P is given by

$$\beta = \frac{D\lambda}{d} \qquad \text{(i)}$$

where λ, is wavelength of monochromatic light source.
Also, from Huygen's principle

$$\mu = \frac{\lambda}{\lambda_w} = \text{refractive index}$$

In water

$$\beta' = \frac{D\lambda_w}{d} \qquad \text{(ii)}$$

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

$$\frac{\beta}{\beta'} = \frac{\lambda}{\lambda_w} \Rightarrow \beta' = \frac{\lambda_w}{\lambda}\beta = \frac{\beta}{\mu}$$

Given $\beta = 0.4\,\text{mm}$, $\mu = \frac{4}{3}$, we have

$$\beta' = \frac{0.4}{(4/3)} = 0.3 \text{ mm}$$

56. When wavelength (λ) of monochromatic light is incident, then width of slit is given by

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

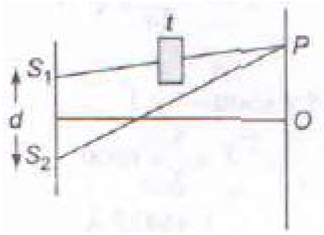
Given, D = 1m, $\lambda = 600\,\text{nm} = 600 \times 10^{-9}\,\text{m}$, $d = \frac{4}{2}$ = 2 mm

$$\therefore \quad \beta = \frac{1 \times 600 \times 10^{-9}}{2 \times 10^{-3}} = 0.3 \times 10^{-3}\text{m} \qquad = 0.3 \text{ mm}$$

57. When a thin film is placed in the path of one of the beams, then the optical path of that beam gets longer. The path difference is

$$\Delta x = (\mu - 1)t$$

Where μ is refractive index, t is thickness.



Given, $\mu = 1.5,\ t = 2\times10^{-6}\,m$

$\therefore \quad \Delta x = (1.5-1)\times 2\times10^{-6} = 10^{-6}\,m = 1\mu m$

Also path difference $\Delta x = \frac{dy}{D} \quad \Rightarrow \quad y = \frac{D}{d}\Delta x$

Also fringe width is given by

$$\beta = \frac{D\lambda}{d} = \frac{D}{d}\times 500\times10^{-9} = \frac{D}{d}\times 0.5\mu m$$

$$y = \frac{D}{d}\times 1\mu m = 2\times\frac{D}{d}\times\frac{1}{2}\mu m = 2\beta$$

Hence, central maxima shifts upward by nearly two fringes.

58. Given, For air, $\mu = 1,\ \lambda = 5890\,Å = 5.89\times10^{-7}\,m$, r = 0

The condition for destructive interference in reflected light

$$2\mu t\cos r = n\lambda$$

For minimum thickness, n =1, so, $2\mu r\cos r = \lambda$

or $\quad t = \frac{\lambda}{2\mu\cos r} = \frac{5.89\times10^{-7}}{2\times1\times1} = 2.945\times10^{-7}\,m$

59. Here $X_3 = X_5$

$$\frac{3D\lambda}{2d} = \frac{5D\lambda'}{2d}$$

$\Rightarrow \ 3\lambda = 5\lambda' \quad$ or $\quad \frac{\lambda'}{\lambda} = \frac{3}{5}$

$$\lambda' = \frac{3}{5}\times 700\,nm = 420\text{ nm}$$

60. Let a_1 and a_2 be the amplitudes of the waves and intensities I_1 and I_2, then

$$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{16}{9}$$

$$\therefore \quad \frac{a_1}{a_2} = \frac{4}{3}$$

Diffraction of Light

1. When a Young's double slit set up for interference shifted from air to within water then the fringe width decreases.

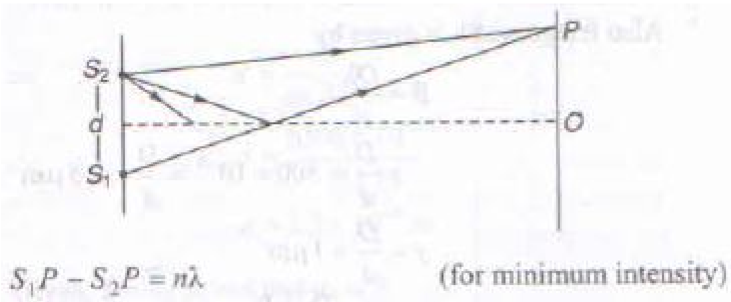
2. The band width is inversely proportional to the distance between the slits d as

$$\beta = \frac{\lambda D}{d}, \ \beta \propto \frac{1}{d}$$

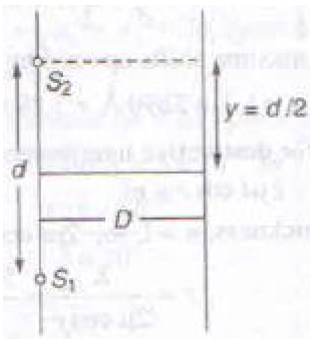
3. Given, $d = 1 \times 10^{-3}$ m, $\lambda = 500 \times 10^{-9}$ m and D = 1m

Fringe separation $\beta = \frac{\lambda D}{d} = \frac{500 \times 10^{-9} \times 1}{1 \times 10^{-3}} = 500 \times 10^{-6} = 0.5 \times 10^{-3}$ m = 0.5 mm

4. The path difference $S_1P - S_2P$ is a whale number of wavelength, the fringe at P is dark no bright. So



5. We have the Young's double slit experiment given by



From the question, we see that the distance between the slits is equal to d and the distance between the slit and screen is equal to D. Hence for the nth dark fringe, we have

$$(2n-1)\frac{D\lambda}{2d} = \frac{d}{2}$$

Hence, we get $\lambda = \frac{d^2}{(2n-1)D} = \frac{d^2}{D}$ for n =1

6. In the ease of Young's double slit experiment. A slit S is necessary if we use an ordinary extended source of light and A slit S is not needed if we use a spatially Coherent source of light.

7. $\beta = \frac{\lambda D}{d} \Rightarrow$ If D becomes twice and d becomes half. So, β becomes four times.

8. For principle maxima in grating spectra

$$n = \frac{1}{\lambda N} = \frac{1}{6.25 \times 10^{-7} \times 2 \times 10^{5}} = 8$$

$\therefore$ Number of maxima = 2n + 1 = 2 × 8 + 1 = 17.

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

The e sinθ = λ or $e\theta = \lambda$ or $\theta = \frac{\lambda}{e}$ (∵ θ = sin θ, when θ small)

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

10. The phase difference (ϕ) between the wavelets from the top edge and the bottom edges of the slit is $\phi = \frac{2\pi}{\lambda}$ (d sinθ) where d is the slit width.

The first minima of the diffraction pattern occur sat $\sin = \frac{\lambda}{d}$

So, $\phi = \frac{2\pi}{\lambda}\left(d \times \frac{\lambda}{d}\right) = 2\pi$.

11. The central maxima lies between the first minima on sides. The angular width of central maxima $= 2\theta = \frac{2\lambda}{d}$.

12. Slit width, $w = \frac{D\lambda}{d}$

Given, D = 80 cm = 80 × 10^{-2} m,

D = 6000Å= 6000 × 10^{-10} m

$$d = \frac{5}{2}\text{mm} = \frac{5 \times 10^{-3}}{2}\text{m}$$

$$\therefore \quad w = \frac{80 \times 10^{-2} \times 600 \times 10^{-10} \times 2}{5 \times 10^{-3}}$$

w = 0.192 × 10^{-3} m = 0.192 mm.

17. For the first minima d sin θ = λ

$$\Rightarrow \sin\theta = \frac{\lambda}{d}$$

$$\theta = \sin^{-1}\left[\frac{5000 \times 10^{-10}}{0.001 \times 10^{-3}}\right] = 30^{\circ}$$

21. Width of the diffraction band is given by

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

where D = distance between slit and the screen.

λ = wavelength of light used and

d = width of slit.

Hence, width of the diffraction band varies directly distance between the slit and the screen.

22. The average distance of nth Fresnel zone from observation point will be at a distance $b + \frac{n\lambda}{2}$.

23. $x = \frac{(2n+1)\lambda D}{2a}$

For red light, $x = \frac{(4+1)D}{2a} \times 6500$

For unknown wavelength of light,

$$x = \frac{(6+1)D}{2a} \times \lambda$$

Accordingly

$\therefore$ $5 \times 6500 = 7 \times \lambda$

$\Rightarrow$ $\lambda = \frac{5}{7} \times 6500$ = 4642.8 Å.

24. The distance first diffraction minimum from the central principal maximum.

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

$\frac{x}{D} = \frac{\lambda}{d}$ or $d = \frac{\lambda}{\sin\theta}$

$$\Rightarrow \sin\theta = \frac{\lambda}{d} = \frac{5000 \times 10^{-8}}{1 \times 10^{-4}}$$

$$\sin\theta = 0.5 = \sin 30^\circ$$

$\theta = 30^\circ$.

25. Condition for nth secondary minimum is that path difference

$$= a\sin\theta_n = n\lambda$$

nth secondary maximum is part difference $= a\sin\theta_n = (2n+1)\frac{\lambda}{2}$

For 1st minimum, λ = 5500 Å, $\theta_n = 30^\circ$

$a \sin 30^\circ = \lambda$ …(i)

For 2nd maximum path difference

$$= a\sin\theta_n = (2+1)\frac{\lambda}{2} \quad \text{…(ii)}$$

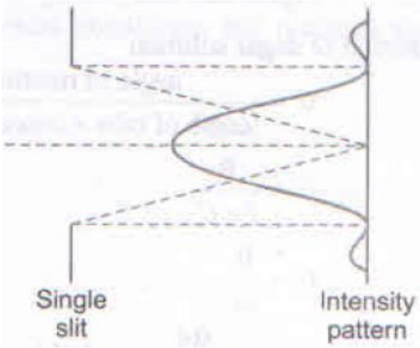
Dividing Eq. (i) by Eq. (ii), we get

$$\frac{\frac{1}{2}}{\sin\theta_n} = \frac{2}{3}$$

$$\Rightarrow \sin\theta_n = \frac{3}{4}$$

$\Rightarrow$ $\theta_n = \sin^{-1}\left(\frac{3}{4}\right)$.

26. The following diagram shows a single slit diffraction pattern.



As is clear from above diagram, in single slit diffraction, the central fringe has maximum intensity and has width double then other fringes. hence, none of the options are true.

27. In single slit diffraction experiment, width of central maxima

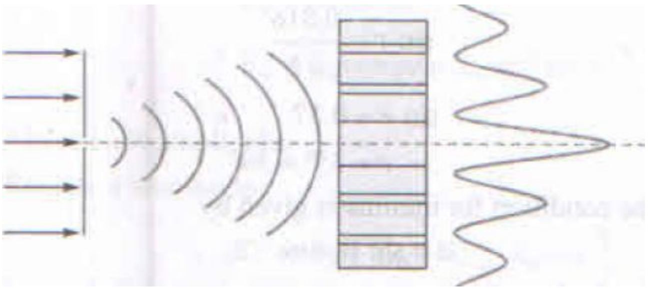
$$y = \frac{2\lambda D}{d}$$

$$\frac{y_1}{y_2} = \frac{\lambda_1}{\lambda_2} \times \frac{d_2}{d_1} = \frac{400}{600} \times \frac{d/2}{d} = \frac{1}{3}$$

$$y_2 = 3y$$

28. The fine rulings, each 0.5 μm wide, on a compact disc function as a diffraction grating. When a small source of white light illuminates a disc, the light is diffracted from the rulings.

29. The following ray diagram shows the single slit diffraction pattern.



This is guided by Huygen's principle. The properties of the system are wholly dependent on the ratio $\frac{\lambda}{\beta}$. where λ is wavelength and β the width of slit.

Angular width $= \frac{\lambda}{\beta}$.

30. When light is incident on a diffraction grating then zero order principal maximum will have only white colour.

31. To see the diffraction pattern, wavelength of radiation must be of the order of the dimensions of the slit. But here slit width 0.6 mm is very much large in comparison to wavelength of X-ray (λ=1Å or 10^{-7} mm). Therefore no diffraction pattern is observed.

Topic 4: Polarisation of Light

1. Polarising angle,

$$\tan i = \frac{1}{\sin C}$$

$\therefore \quad \cot i = \sin\left(\sin^{-1}\left(\frac{3}{5}\right)\right)$ or $\tan i = \frac{5}{3}$ or $i = \tan^{-1}\left(\frac{5}{3}\right)$.

2. Critical angle C = $\sin^{-1}$ (0.6)

$\sin(C) = 0.6$

$$\mu = \frac{1}{\sin C} = \frac{1}{0.6}$$

Polarising angle $i_p = \tan^{-1}(\mu) = \tan^{-1}\left(\frac{1}{0.6}\right)$

$= \tan^{-1}(1.6667)$.

3. From Brewster's law, $\mu = \tan i_p$

$$\Rightarrow \frac{c}{v} = \tan 60^\circ = \sqrt{3}$$

$$\Rightarrow \quad v = \frac{c}{\sqrt{3}} = \frac{3\times10^8}{\sqrt{3}} = \sqrt{3}\times10^8 \text{ ms}^{-1}.$$

4. Refractive index $\mu = \tan\theta = \sqrt{2}$

Now according to snell's law

$$\sqrt{2} = \frac{\sin(54.74)}{\sin r}$$

$$\sin r = \frac{0.816}{\sqrt{2}}$$

sin r = 0.75

r = 35º = 30º

5. The condition for minima is given by

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

For n = l, we have

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

If angle small, then $\sin\theta = 0$

$$\Rightarrow d\theta = \lambda$$

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

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

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

$\frac{\lambda'}{\lambda} = \frac{\omega'}{\omega}$ or $\lambda' = \lambda\frac{\omega'}{\omega}$ or $\lambda' = 6000\times0.7$

= 4200 Å

6. Polarisation is not shown by sound waves.

7. Intensity of polarized light from first polarizer $= \frac{100}{2} = 50$

$$I = I_0 \cos^2\theta = 50 \cos^2 60^o = \frac{50}{4} = 12.5$$

8. The magnitude of electric field vector varies periodically with time because it is the form of electromagnetic wave.

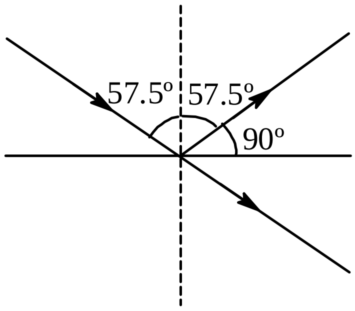
11. According to Malus's law

$$I = I_0 \cos^2\theta = I_0(\cos^2 60^o) = I_0 \times \left(\frac{1}{2}\right)^2 = \frac{I_0}{4}$$

12. If an unpolarised light is converted into plane polarized light by passing through a Polaroid its intensity becomes half.

13. Some crystals such as tourmaline and sheets of iodosulphate of quinine have the property of strongly absorbing the light with vibrations perpendicular to a specific direction (called transmission axis) transmitting the light with vibration parallel to it. This selective absorption of light is called dichroism.

14. When light ray incident at polarizing angle, then angle of incidence (i) and angle of reflection (r) are equal. Also angle between reflected and refracted ray is 90º.



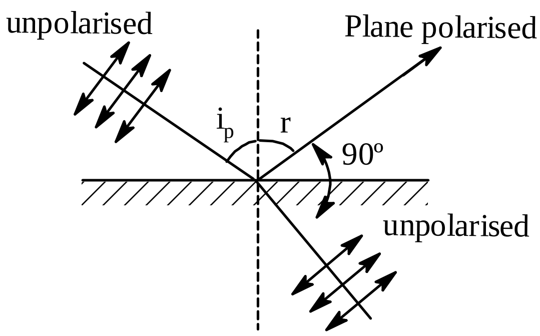
Thus, angle between incident ray and refracted rays = 57.5º + 57.5º + 90º = 205º.

15. According to Malus law $I = I_0 \cos^2\theta$

Intensity of polarized light $= \frac{I_0}{2}$

$\therefore$ Intensity of untransmitted light $= I_0 - \frac{I_0}{2} = \frac{I_0}{2}$.

16. By Brewster's law reflected ray is perpendicular to refracted ray.



The reflected ray so obtained is plane polarized having electric vector in the plane of incidence.

17. Refractive index of a medium

$\mu = \tan i_p$

where i_p = Brewster's angle

$\Rightarrow\ i_p = \tan^{-1}\mu$

18. Specific rotation of sugar solution

$$\alpha = \frac{\text{angle of rotation}}{\text{length of tube} \times \text{concentraction}} = \frac{\theta}{l \times C}$$

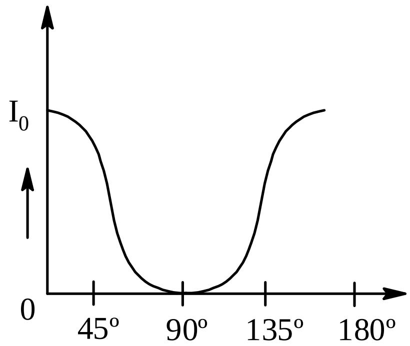
$$C = \frac{\theta}{l\alpha} = \frac{0.4}{0.25 \times 0.01} = 160\ \text{kgm}^{-3}.$$

Thus, purity of sugar solution $= \frac{160}{200} \times 100 = 80\%$.

19. According to law of Malus, when a beam of completely polarized light is incident on analyser, the intensity of light (I) transmitted from the analyser directly as the square of the consine of the angle (θ) planes of transmission of analyser and polarizer.

$I \propto \cos^2\theta$

and $I = I_0 \cos^2\theta$ ...(i)



where I_0 = intensity of the light form polarizer.

From Eq. (a), we note that if the transmission axes of polarizer and analyzer are parallel (i.e., θ = 0° or 180°), then $I = I_0$. It means that intensity of transmitted light is maximum. When the transmission axes of polarizer and analyzer are perpendicular (i.e. θ = 90°), the $I = I_0 \cos^2 90° = 0$. It means the intensity of transmitted light is minimum.

On plotting a graph between I and θ as given by relation (i), we get the curve as shown in figure.

20. Refractive index of glass, $\mu_g = \tan\theta_p$

where θ_p = polarizing angle

$\Rightarrow\ \mu_g = \tan 60° = \sqrt{3}$

Now, $\mu_g = \frac{c}{v_g}$

$\therefore\ \frac{c}{v_g} = \sqrt{3} \quad \Rightarrow \quad v_g = \frac{3 \times 10^8}{\sqrt{3}} = \sqrt{3} \times 10^8\ \text{ms}^{-1}.$

21. Sound waves are longitudinal and longitudinal waves cannot be polarized.

23. When two plane-polarised waves are superimposed, then under certain conditions, the resultant light vector rotates with a constant magnitude in a plane perpendicular to the direction of propagation. The tip of the vector traces a circle and the light is said to be circularly polarized.

To form circularly polarized light

$$E_x = E_0 \sin \omega t$$

$$E_y = E_0 \cos \omega t = E_0 \sin\left(\omega t + \frac{\pi}{2}\right)$$

where E_0 is amplitude.

Resultant amplitude

$$|E|^2 = E_0 + E_0 + 2E_0 \cdot E_0 \cos\frac{\pi}{2}$$

$$|E|^2 = E_0\sqrt{2} = \text{ constant (a).}$$

24. Plane containing the direction of vibration and wave motion is called plane of polarization. Plane of vibration is perpendicular to the direction of propagation and also perpendicular to the plane of polarization. Therefore, angle between plane of polarization and direction of propagation is 0º.

25. We see two images of dot. One image is stationary and other image rotates about it.

26. Electric field vector is the form of electromagnetic wave hence, it varies periodically with time.

27. If unpolarised light is incident at polarizing angle, then reflected light is completely i.e., 100% polarized.

28. Refractive index $\mu = \tan i_p = \tan 60° = \sqrt{3}$

So, velocity of refracted ray inside the material

$$v = \frac{c}{\mu} = \frac{3\times10^8}{\sqrt{3}} = \sqrt{3}\times10^8 \text{ ms}^{-1}.$$

29. For the study of the helical structure of nucleic acids, polarization property of electromagnetic radiation is generally used.