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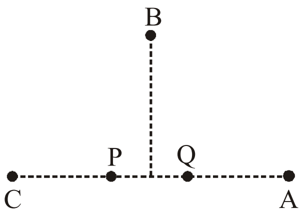
Wave Optics

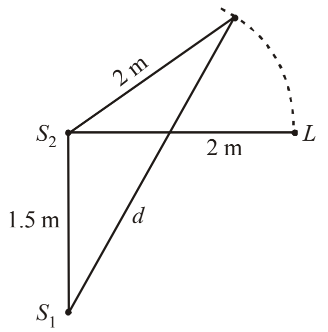
TOPIC 1 Wavefront, Interference of Light, Coherent and Incoherent Sources

1. In the figure below, P and Q are two equally intense coherent sources emitting radiation of wavelength 20 m. The separation between P and Q is 5 m and the phase of P is ahead of that of Q by 90º. A, B and C are three distinct points of observation, each equidistant from the midpoint of PQ. The intensities of radiation at A, B, C will be in the ratio : **[Sep. 06, 2020 (I)]**



(a) 0 : 1 : 4 (b) 2 : 1 : 0
(c) 0 : 1 : 2 (d) 4 : 1 : 0

2. Two coherent sources of sound, S_1 and S_2, produce sound waves of the same wavelength, $\lambda = 1$ m, in phase. S_1 and S_2 are placed 1.5 m apart (see fig.). A listener, located at L, directly in front of S_2 finds that the intensity is at a minimum when he is 2 m away from S_2. The listener moves away from S_1, keeping his distance from S_2 fixed. The adjacent maximum of intensity is observed when the listener is at a distance d from S_1. Then, d is : **[Sep. 05, 2020 (II)]**



(a) 12m (b) 5m (c) 2m (d) 3m

3. Two light waves having the same wavelength λ in vacuum are in phase initially. Then the first wave travels a path L_1 through a medium of refractive index n_1 while the second wave travels a path of length L_2 through a medium of refractive index n_2. After this the phase difference between the two waves is : **[Sep. 03, 2020 (II)]**

(a) $\frac{2\pi}{\lambda}\left(\frac{L_2}{n_1} - \frac{L_1}{n_2}\right)$ (b) $\frac{2\pi}{\lambda}\left(\frac{L_1}{n_1} - \frac{L_2}{n_2}\right)$

(c) $\frac{2\pi}{\lambda}(n_1 L_1 - n_2 L_2)$ (d) $\frac{2\pi}{\lambda}(n_2 L_1 - n_1 L_2)$

4. In an interference experiment the ratio of amplitudes of coherent waves is $\frac{a_1}{a_2} = \frac{1}{3}$. The ratio of maximum and minimum intensities of fringes will be : **[8 April 2019 I]**

(a) 2 (b) 18 (c) 4 (d) 9

5. Two coherent sources produce waves of different intensities which interfere. After interference, the ratio of the maximum intensity to the minimum intensity is 16. The intensity of the waves are in the ratio: **[9 Jan. 2019 I]**

(a) 16 : 9 (b) 25 : 9 (c) 4 : 1 (d) 5 : 3

6. On a hot summer night, the refractive index of air is smallest near the ground and increases with height from the ground. When a light beam is directed horizontally, the Huygens' principle leads us to conclude that as it travels, the light beam : **[2015]**

(a) bends downwards
(b) bends upwards
(c) becomes narrower
(d) goes horizontally without any deflection

7. Interference pattern is observed at 'P' due to superimposition of two rays coming out from a source 'S' as shown in the figure. The value of 'l' for which maxima is obtained at 'P' is:

(R is perfect reflecting surface) **[Online April 12, 2014]**

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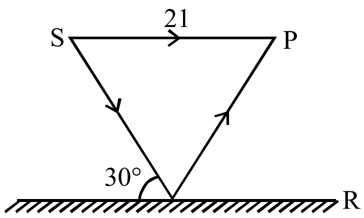


(a) $l = \frac{2n\lambda}{\sqrt{3}-1}$ (b) $l = \frac{(2n-1)\lambda}{2(\sqrt{3}-1)}$

(c) $l = \frac{(2n-1)\lambda\sqrt{3}}{4(2-\sqrt{3})}$ (d) $l = \frac{(2n-1)\lambda}{\sqrt{3}-1}$

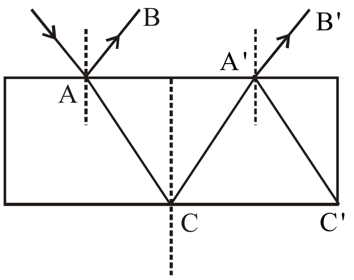
8. Two monochromatic light beams of intensity 16 and 9 units are interfering. The ratio of intensities of bright and dark parts of the resultant pattern is: **[Online April 11, 2014]**

(a) $\frac{16}{9}$ (b) $\frac{4}{3}$ (c) $\frac{7}{1}$ (d) $\frac{49}{1}$

9. n identical waves each of intensity I_0 interfere with each other. The ratio of maximum intensities if the interference is (i) coherent and (ii) incoherent is : **[Online April 23, 2013]**

(a) n^2 (b) $\frac{1}{n}$ (c) $\frac{1}{n^2}$ (d) n

10. A ray of light of intensity I is incident on a parallel glass slab at point A as shown in diagram. It undergoes partial reflection and refraction. At each reflection, 25% of incident energy is reflected. The rays AB and A'B' undergo interference. The ratio of I_{max} and I_{min} is : **[Online April 9, 2013]**



(a) 49 : 1 (b) 7 : 1 (c) 4 : 1 (d) 8 : 1

11. Two coherent plane light waves of equal amplitude makes a small angle α (<< 1) with each other. They fall almost normally on a screen. If λ is the wavelength of light waves, the fringe width Δx of interference patterns of the two sets of waves on the screen is **[Online May 19, 2012]**

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

12. This question has a paragraph followed by two statements, Statement – 1 and Statement – 2. Of the given four alternatives after the statements, choose the one that describes the statements.

A thin air film is formed by putting the convex surface of a plane-convex lens over a plane glass plate. With monochromatic light, this film gives an interference pattern due to light reflected from the top (convex) surface and the bottom (glass plate) surface of the film.

Statement – 1 : When light reflects from the air-glass plate interface, the reflected wave suffers a phase change of π.

Statement – 2 : The centre of the interference pattern is dark. **[2011]**

(a) Statement – 1 is true, Statement – 2 is true, Statement – 2 is the correct explanation of Statement – 1.
(b) Statement – 1 is true, Statement – 2 is true, Statement – 2 is not the correct explanation of Statement – 1.
(c) Statement – 1 is false, Statement – 2 is true.
(d) Statement – 1 is true, Statement – 2 is false.

Directions : Questions number 13-15 are based on the following paragraph.

An initially parallel cylindrical beam travels in a medium of refractive index $\mu(I) = \mu_0 + \mu_2 I$, where μ_0 and μ_2 are positive constants and I is the intensity of the light beam. The intensity of the beam is decreasing with increasing radius

13. As the beam enters the medium , it will **[2010]**
(a) diverge
(b) converge
(c) diverge near the axis and converge near the periphery
(d) travel as a cylindrical beam

14. The initial shape of the wavefront of the beam is **[2010]**
(a) convex
(b) concave
(c) convex near the axis and concave near the periphery
(d) planar

15. The speed of light in the medium is **[2010]**
(a) minimum on the axis of the beam
(b) the same everywhere in the beam
(c) directly proportional to the intensity I
(d) maximum on the axis of the beam

16. To demonstrate the phenomenon of interference, we require two sources which emit radiation **[2003]**
(a) of nearly the same frequency
(b) of the same frequency
(c) of different wavelengths
(d) of the same frequency and having a definite phase relationship

TOPIC 2 Young's Double Slit Experiment

17. A young's double-slit experiment is performed using monocromatic light of wavelength λ. The inntensity of light at a point on the screen, where the path difference is λ, is K units. The intensity of light at a point where the path difference is $\frac{\lambda}{6}$ is given by $\frac{nK}{12}$, where n is an integer. The value of n is ______. **[NA Sep. 06, 2020 (II)]**

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18. In a Young's double slit experiment, light of 500 nm is used to produce an interference pattern. When the distance between the slits is 0.05 mm, the angular width (in degree) of the fringes formed on the distance screen is close to : **[Sep. 03, 2020 (I)]**

(a) 0.17° (b) 0.57°
(c) 1.7° (d) 0.07°

19. Interference fringes are observed on a screen by illuminating two thin slits 1 mm apart with a light source (λ = 632.8 nm). The distance between the screen and the slits is 100 cm. If a bright fringe is observed on a screen at a distance of 1.27 mm from the central bright fringe, then the path difference between the waves, which are reaching this point from the slits is close to : **[Sep. 02, 2020 (I)]**

(a) 1.27 μm (b) 2.87 nm
(c) 2 nm (d) 2.05 μm

20. In a Young's double slit experiment, 16 fringes are observed in a certain segment of the screen when light of wavelength 700 nm is used. If the wavelength of light is changed to 400 nm, the number of fringes observed in the same segment of the screen would be : **[Sep. 02, 2020 (II)]**

(a) 24 (b) 30
(c) 18 (d) 28

21. In a Young's double slit experiment 15 fringes are observed on a small portion of the screen when light of wavelength 500 nm is used. Ten fringes are observed on the same section of the screen when another light source of wavelength λ is used. Then the value of λ is (in nm) ______. **[NA 9 Jan 2020 II]**

22. In a double-slit experiment, at a certain point on the screen the path difference between the two interfering waves is $\frac{1}{8}$ th of a wavelength. The ratio of the intensity of light at that point to that at the centre of a bright fringe is: **[8 Jan 2020 II]**

(a) 0.853 (b) 0.672 (c) 0.568 (d) 0.760

23. In a Young's double slit experiment, the separation between the slits is 0.15 mm. In the experiment, a source of light of wavelength 589 nm is used and the interference pattern is observed on a screen kept 1.5 m away. The separation between the successive bright fringes on the screen is: **[7 Jan 2020 II]**

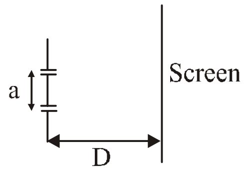
(a) 6.9 mm (b) 3.9 mm (c) 5.9 mm (d) 4.9 mm

24. In a double slit experiment, when a thin film of thickness t having refractive index μ is introduced in front of one of the slits, the maximum at the centre of the fringe pattern shifts by one fringe width. The value of t is ($\approx$ is the wavelength of the light used) : **[12 April 2020 I]**

(a) $\frac{2\lambda}{(\mu-1)}$ (b) $\frac{\lambda}{2(\mu-1)}$

(c) $\frac{\lambda}{(\mu-1)}$ (d) $\frac{\lambda}{(2\mu-1)}$

25. The figure shows a Young's double slit experimental setup. It is observed that when a thin transparent sheet of thickness t and refractive index ¼ is put in front of one of the slits, the central maximum gets shifted by a distance equal to n fringe widths. If the wavelength of light used is », t will be: **[9 April 2019 I]**



(a) $\frac{2nD\lambda}{a(\mu-1)}$ (b) $\frac{nD\lambda}{a(\mu-1)}$

(c) $\frac{D\lambda}{a(\mu-1)}$ (d) $\frac{2D\lambda}{a(\mu-1)}$

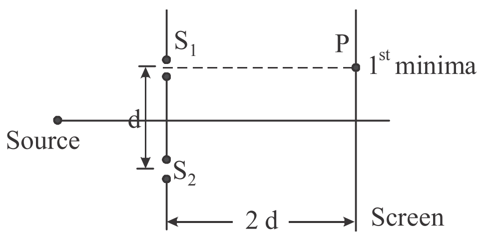
26. In a Young's double slit experiment, the path difference, at a certain point on the screen, betwen two interfering waves is $\frac{1}{8}$th of wavelength. The ratio of the intensity at this point to that at the centre of a bright fringe is close to: **[11 Jan 2019 I]**

(a) 0.74 (b) 0.85 (c) 0.94 (d) 0.80

27. In a Young's double slit experiment with slit separation 0.1 mm, one observes a bright fringe at angle $\frac{1}{40}$ rad by using light of wavelength λ_1 When the light of wavelength λ_2 is used a bright fringe is seen at the same angle in the same set up. Given that λ_1 and λ_2 are in visible range (380 nm to 740 nm), their values are: **[10 Jan. 2019 I]**

(a) 625 nm, 500 nm (b) 380 nm, 525 nm
(c) 380 nm, 500 nm (d) 400 nm, 500 nm

28. Consider a Young's double slit experiment as shown in figure. What should be the slit separation d in terms of wavelength λ such that the first minima occurs directly in front of the slit (S_1)? **[10 Jan 2019 II]**



(a) $\frac{\lambda}{2(\sqrt{5}-2)}$ (b) $\frac{\lambda}{(\sqrt{5}-2)}$

(c) $\frac{\lambda}{2(5-\sqrt{2})}$ (d) $\frac{\lambda}{(5-\sqrt{2})}$

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29. In a Young's double slit experiment, the slits are placed 0.320 mm apart. Light of wavelength λ = 500 nm is incident on the slits. The total number of bright fringes that are observed in the angular range $-30° \le \theta \le 30°$ is **[9 Jan 2019 II]**

(a) 640 (b) 320 (c) 321 (d) 641

30. In a Young's double slit experiment, slits are separated by 0.5 mm, and the screen is placed 150 cm away. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes on the screen. The least distance from the common central maximum to the point where the bright fringes due to both the wavelengths coincide is : **[2017]**

(a) 9.75 mm (b) 15.6 mm (c) 1.56 mm (d) 7.8 mm

31. In a Young's double slit experiment with light of wavelength λ the separation of slits is d and distance of screen is D such that D >> d >> λ. If the fringe width is β, the distance from point of maximum intensity to the point where intensity falls to half of maximum intensity on either side is: **[Online April 11, 2015]**

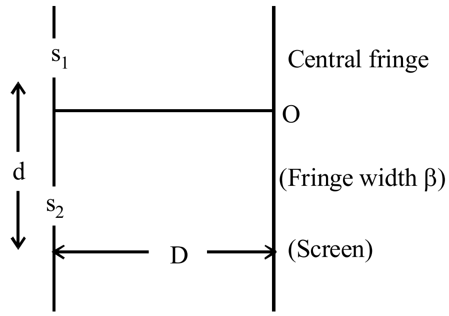
(a) $\frac{\beta}{6}$ (b) $\frac{\beta}{3}$ (c) $\frac{\beta}{4}$ (d) $\frac{\beta}{2}$

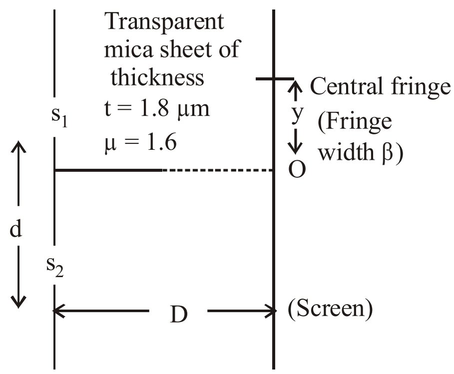
32. In a Young's double slit experiment, the distance between the two identical slits is 6.1 times larger than the slit width. Then the number of intensity maxima observed within the central maximum of the single slit diffraction pattern is: **[Online April 19, 2014]**

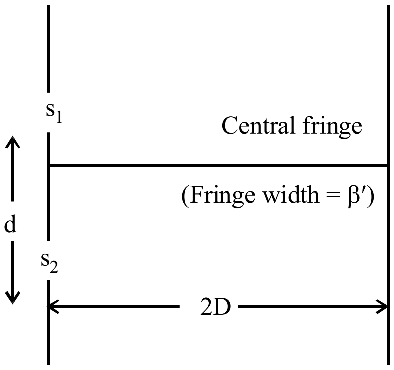
(a) 3 (b) 6 (c) 12 (d) 24

33. Using monochromatic light of wavelength λ, an experimentalist sets up the Young's double slit experiment in three ways as shown.

If she observes that y = β', the wavelength of light used is: **[Online April 9, 2014]**

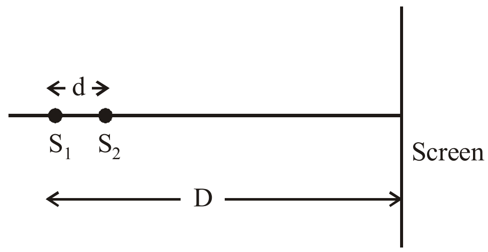






(a) 520 nm (b) 540 nm (c) 560 nm (d) 580 nm

34. Two coherent point sources S_1 and S_2 are separated by a small distance 'd' as shown. The fringes obtained on the screen will be **[2013]**



(a) points (b) straight lines

(c) semi-circles (d) concentric circles

35. The source that illuminates the double - slit in 'double - slit interference experiment' emits two distinct monochromatic waves of wavelength 500 nm and 600 nm, each of them producing its own pattern on the screen. At the central point of the pattern when path difference is zero, maxima of both the patterns coincide and the resulting interference pattern is most distinct at the region of zero path difference. But as one moves out of this central region, the two fringe systems are gradually out of step such that maximum due to on wavelength coincides with the minimum due to the other and the combined fringe system becomes completely indistinct. This may happen when path difference in nm is: **[Online April 25, 2013]**

(a) 2000 (b) 3000 (c) 1000 (d) 1500

36. A thin glass plate of thickness is $\frac{2500}{3}\lambda$ (λ is wavelength of light used) and refractive index μ = 1.5 is inserted between one of the slits and the screen in Young's double slit experiment. At a point on the screen equidistant from the slits, the ratio of the intensities before and after the introduction of the glass plate is : **[Online April 25, 2013]**

(a) 2 : 1 (b) 1 : 4 (c) 4 : 1 (d) 4 : 3

37. This question has Statement-1 and Statement-2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

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Statement-1: In Young's double slit experiment, the number of fringes observed in the field of view is small with longer wavelength of light and is large with shorter wavelength of light.

Statement-2: In the double slit experiment the fringe width depends directly on the wavelength of light.

[Online April 22, 2013]

(a) Statement-1 is true, Statement-2 is true and the Statement-2 is correct explanation of the Statement-1.
(b) Statement-1 is false and the Statement-2 is true.
(c) Statement-1 is true Statement-2 is true and the Statement-2 is not correct explanation of the Statement-1.
(d) Statement-1 is true and the Statement-2 is false.

38. In Young's double slit experiment, one of the slit is wider than other, so that amplitude of the light from one slit is double of that other slit. If I_m be the maximum intensity, the resultant intensity I when they interfere at phase difference ϕ is given by : **[2012]**

(a) $\frac{I_m}{9}(4+5\cos\phi)$ (b) $\frac{I_m}{3}\left(1+2\cos^2\frac{\phi}{2}\right)$
(c) $\frac{I_m}{5}\left(1+4\cos^2\frac{\phi}{2}\right)$ (d) $\frac{I_m}{9}\left(1+8\cos^2\frac{\phi}{2}\right)$

39. In Young's double slit interference experiment, the slit widths are in the ratio 1 : 25. Then the ratio of intensity at the maxima and minima in the interference pattern is **[Online May 26, 2012]**

(a) 3 : 2 (b) 1 : 25 (c) 9 : 4 (d) 1 : 5

40. The maximum number of possible interference maxima for slit separation equal to 1.8λ, where λ is the wavelength of light used, in a Young's double slit experiment is **[Online May 12, 2012]**

(a) zero (b) 3 (c) infinite (d) 5

41. In a Young's double slit experiment with light of wavelength λ, fringe pattern on the screen has fringe width β. When two thin transparent glass (refractive index μ) plates of thickness t_1 and t_2 ($t_1 > t_2$) are placed in the path of the two beams respectively, the fringe pattern will shift by a distance **[Online May 7, 2012]**

(a) $\frac{\beta(\mu-1)}{\lambda}\left(\frac{t_1}{t_2}\right)$ (b) $\frac{\mu\beta}{\lambda}\frac{t_1}{t_2}$
(c) $\frac{\beta(\mu-1)}{\lambda}(t_1-t_2)$ (d) $(\mu-1)\frac{\lambda}{\beta}(t_1+t_2)$

42. At two points P and Q on screen in Young's double slit experiment, waves from slits S_1 and S_2 have a path difference of 0 and $\frac{\lambda}{4}$, respectively. The ratio of intensities at P and Q will be : **[2011 RS]**

(a) 2 : 1 (b) $\sqrt{2}$: 1 (c) 4 : 1 (d) 3 : 2

43. In a Young's double slit experiment, the two slits act as coherent sources of wave of equal amplitude A and wavelength λ. In another experiment with the same arrangement the two slits are made to act as incoherent sources of waves of same amplitude and wavelength. If the intensity at the middle point of the screen in the first case is I_1 and in the second case is I_2, then the ratio $\frac{I_1}{I_2}$ is **[2011 RS]**

(a) 2 (b) 1 (c) 0.5 (d) 4

44. A mixture of light, consisting of wavelength 590 nm and an unknown wavelength, illuminates Young's double slit and gives rise to two overlapping interference patterns on the screen. The central maximum of both lights coincide. Further, it is observed that the third bright fringe of known light coincides with the 4th bright fringe of the unknown light. From this data, the wavelength of the unknown light is: **[2009]**

(a) 885.0 nm (b) 442.5 nm
(c) 776.8 nm (d) 393.4 nm

45. In a Young's double slit experiment the intensity at a point where the path difference is $\frac{\lambda}{6}$ (λ being the wavelength of light used) is I. If I_0 denotes the maximum intensity, $\frac{I}{I_0}$ is equal to **[2007]**

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

46. A Young's double slit experiment uses a monochromatic source. The shape of the interference fringes formed on a screen is **[2005]**

(a) circle (b) hyperbola
(c) parabola (d) straight line

47. The maximum number of possible interference maxima for slit-separation equal to twice the wavelength in Young's double-slit experiment is **[2004]**

(a) three (b) five (c) infinite (d) zero

TOPIC 3 Diffraction, Polarisation of Light and Resolving Power

48. A beam of plane polarised light of large cross-sectional area and uniform intensity of 3.3 Wm^{-2} falls normally on a polariser (cross sectional area $3 \times 10^{-4}\ m^2$) which rotates about its axis with an angular speed of 31.4 rad/s. The energy of light passing through the polariser per revolution, is close to : **[Sep. 04, 2020 (I)]**

(a) 1.0×10^{-5} J (b) 1.0×10^{-4} J
(c) 1.5×10^{-4} J (d) 5.0×10^{-4} J

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49. Orange light of wavelength 6000×10^{-10} m illuminates a single slit of width 0.6×10^{-4} m. The maximum possible number of diffraction minima produced on both sides of the central maximum is ____________. **[NA Sep. 04, 2020 (II)]**

50. The aperture diameter of telescope is 5m. The separation between the moon and the earth is 4×10^5 km. With light of wavelength of 5500 Å, the minimum separation between objects on the surface of moon, so that they are just resolved, is close to: **[9 Jan. 2020 I]**

(a) 60m (b) 20m (c) 200m (d) 600m

51. A polarizer - analyser set is adjusted such that the intensity of light coming out of the analyser is just 10% of the original intensity. Assuming that the polarizer - analyser set does not absorb any light, the angle by which the analyser need to be rotated further to reduce the output intensity to be zero, is: **[7 Jan. 2020 I]**

(a) 71.6° (b) 18.4° (c) 90° (d) 45°

52. The value of numerical aperature of the objective lens of a microscope is 1.25. If light of wavelength 5000 Å is used, the minimum separation between two points, to be seen as distinct, will be : **[12 April 2019 I]**

(a) 0.24 μm (b) 0.38 μm (c) 0.12 μm (d) 0.48 μm

53. A system of three polarizers P_1, P_2, P_3 is set up such that the pass axis of P_3 is crossed with respect to that of P_1. The pass axis of P_2 is inclined at 60° to the pass axis of P_3. When a beam of unpolarized light of intensity I_o is incident on P_1, the intensity of light transmitted by the three polarizers is I. The ratio (I_o/I) equals (nearly) : **[12 April 2019 II]**

(a) 5.33 (b) 16.00 (c) 10.67 (d) 1.80

54. Diameter of the objective lens of a telescope is 250 cm. For light of wavelength 600 nm. Coming from a distant object, the limit of resolution of the telescope is close to: **[9 April 2019 II]**

(a) 1.5×10^{-7} rad(b) 2.0×10^{-7} rad

(c) 3.0×10^{-7} rad (d) 4.5×10^{-7} rad

55. Calculate the limit of resolution of a telescope objective having a diameter of 200 cm, if it has to detect light of wavelength 500 nm coming from a star. **[8 April 2019 II]**

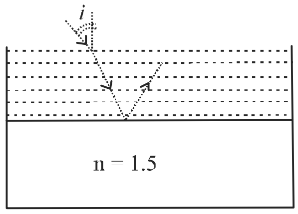
(a) 305×10^{-9} radian (b) 610×10^{-9} radian

(c) 152.5×10^{-9} radian (d) 457.5×10^{-9} radian

56. In a double-slit experiment, green light (5303Å) falls on a double slit having a separation of 19.44 μm and a width of 4.05 μm. The number of bright fringes between the first and the second diffraction minima is : **[11 Jan 2019 II]**

(a) 10 (b) 05 (c) 04 (d) 09

57. Consider a tank made of glass (refractive index 1.5) with a thick bottom. It is filled with a liquid of refractive index μ. A student finds that, irrespective of what the incident angle *i* (see figure) is for a beam of light entering the liquid, the light reflected from the liquid glass interface is never completely polarized. For this to happen, the minimum value of μ is: **[9 Jan. 2019 I]**



(a) $\sqrt{\frac{5}{3}}$ (b) $\frac{3}{\sqrt{5}}$ (c) $\frac{5}{\sqrt{3}}$ (d) $\frac{4}{3}$

58. The angular width of the central maximum in a single slit diffraction pattern is 60°. The width of the slit is 1 μm. The slit is illuminated by monochromatic plane waves. If another slit of same width is made near it, Young's fringes can be observed on a screen placed at a distance 50 cm from the slits. If the observed fringe width is 1 cm, what is slit separation distance?
(i.e. distance between the centres of each slit.) **[2018]**

(a) 25 μm (b) 50 μm (c) 75 μm (d) 100 μm

59. Unpolarized light of intensity I passes through an ideal polarizer A. Another indentical polarizer B is placed behind A. The intensity of light beyond B is found to be $\frac{I}{2}$. Now another identical polarizer C is placed between A and B. The intensity beyond B is now found to be $\frac{I}{8}$. The angle between polarizer A and C is: **[2018]**

(a) 0° (b) 30° (c) 45° (d) 60°

60. Light of wavelength 550 nm falls normally on a slit of width 22.0×10^{-5}cm. The angular position of the second minima from the central maximum will be (in radians) **[Online April 15, 2018]**

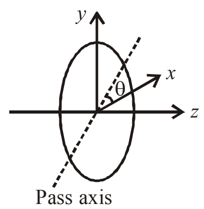
(a) $\frac{\pi}{8}$ (b) $\frac{\pi}{12}$ (c) $\frac{\pi}{4}$ (d) $\frac{\pi}{6}$

61. Unpolarized light of intensity I is incident on a system of two polarizers, A followed by B. The intensity of emergent light is I/2. If a third polarizer C is placed between A and B, the intensity of emergent light is reduced to I/3. The angle between the polarizers A and C is θ. Then **[Online April 16, 2018]**

(a) $\cos\theta = \left(\frac{2}{3}\right)^{1/4}$ (b) $\cos\theta = \left(\frac{1}{3}\right)^{1/4}$

(c) $\cos\theta = \left(\frac{1}{3}\right)^{1/2}$ (d) $\cos\theta = \left(\frac{2}{3}\right)^{1/2}$

62. A plane polarized light is incident on a polariser with its pass axis making angle θ with x-axis, as shown in the figure. At four different values of θ, θ = 8°, 38°, 188° and 218°, the observed intensities are same. What is the angle between the direction of polarization and x-axis **[Online April 15, 2018]**



(a) 203° (b) 45° (c) 98° (d) 128°

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63. An observer is moving with half the speed of light towards a stationary microwave source emitting waves at frequency 10 GHz. What is the frequency of the microwave measured by the observer? (speed of light = $3 \times 10^8\ ms^{-1}$) **[2017]**

(a) 17.3 GHz (b) 15.3 GHz
(c) 10.1 GHz (d) 12.1 GHz

64. A single slit of width 0.1 mm is illuminated by a parallel beam of light of wavelength 6000 Å and diffraction bands are observed on a screen 0.5 m from the slit. The distance of the third dark band from the central bright band is : **[Online April 9, 2017]**

(a) 3mm (b) 9mm (c) 4.5mm (d) 1.5mm

65. A single slit of width *b* is illuminated by a coherent monochromatic light of wavelength λ. If the second and fourth minima in the diffraction pattern at a distance 1 m from the slit are at 3 cm and 6 cm respectively from the central maximum, what is the width of the central maximum? (i.e. distance between first minimum on either side of the central maximum) **[Online April 8, 2017]**

(a) 1.5 cm (b) 3.0 cm (c) 4.5 cm (d) 6.0 cm

66. The box of a pin hole camera, of length L, has a hole of radius a. It is assumed that when the hole is illuminated by a parallel beam of light of wavelength λ the spread of the spot (obtained on the opposite wall of the camera) is the sum of its geometrical spread and the spread due to diffraction. The spot would then have its minimum size (say b_{min}) when : **[2016]**

(a) $a = \sqrt{\lambda L}$ and $b_{min} = \sqrt{4\lambda L}$

(b) $a = \frac{\lambda^2}{L}$ and $b_{min} = \sqrt{4\lambda L}$

(c) $a = \frac{\lambda^2}{L}$ and $b_{min} = \left(\frac{2\lambda^2}{L}\right)$

(d) $a = \sqrt{\lambda l}$ and $b_{min} = \left(\frac{2\lambda^2}{L}\right)$

67. Two stars are 10 light years away from the earth. They are seen through a telescope of objective diameter 30 cm. The wavelength of light is 600 nm. To see the stars just resolved by the telescope, the minimum distance between them should be (1 light year = 9.46×10^{15} m) of the order of : **[Online April 10, 2016]**

(a) 10^8 km (b) 10^{10} km (c) 10^{11} km (d) 10^6 km

68. In Young's double slit experiment, the distance between slits and the screen is 1.0 m and monochromatic light of 600 nm is being used. A person standing near the slits is looking at the fringe pattern. When the separation between the slits is varied, the interference pattern disappears for a particular distance d_0 between the slits. If the angular resolution of the eye is $\frac{1°}{60}$, the value of d_0 is close to : **[Online April 9, 2016]**

(a) 1mm (b) 3mm (c) 2mm (d) 4mm

69. Assuming human pupil to have a radius of 0.25 cm and a comfortable viewing distance of 25 cm, the minimum separation between two objects that human eye can resolve at 500 nm wavelength is : **[2015]**

(a) 100 μm (b) 300 μm (c) 1 μm (d) 30 μm

70. Unpolarized light of intensity I_0 is incident on surface of a block of glass at Brewster's angle. In that case, which one of the following statements is true ? **[Online April 11, 2015]**

(a) reflected light is completely polarized with intensity less than $\frac{I_0}{2}$

(b) transmitted light is completely polarized with intensity less than $\frac{I_0}{2}$

(c) transmitted light is partially polarized with intensity $\frac{I_0}{2}$

(d) reflected light is partially polarized with intensity $\frac{I_0}{2}$

71. Two beams, A and B, of plane polarized light with mutually perpendicular planes of polarization are seen through a polaroid. From the position when the beam A has maximum intensity (and beam B has zero intensity), a rotation of polaroid through $30°$ makes the two beams appear equally bright. If the initial intensities of the two beams are I_A and I_B respectively, then $\frac{I_A}{I_B}$ equals: **[2014]**

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

72. The diameter of the objective lens of microscope makes an angle β at the focus of the microscope. Further, the medium between the object and the lens is an oil of refractive index n. Then the resolving power of the microscope **[Online April 19, 2014]**

(a) increases with decreasing value of n
(b) increases with decreasing value of β
(c) increases with increasing value of $n \sin 2\beta$
(d) increases with increasing value of $\frac{1}{n \sin 2\beta}$

73. A ray of light is incident from a denser to a rarer medium. The critical angle for total internal reflection is θ_{iC} and Brewster's angle of incidence is θ_{iB}, such that $\sin\theta_{iC}/\sin\theta_{iB} = \eta = 1.28$. The relative refractive index of the two media is: **[Online April 19, 2014]**

(a) 0.2 (b) 0.4 (c) 0.8 (d) 0.9

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74. In an experiment of single slit diffraction pattern, first minimum for red light coincides with first maximum of some other wavelength. If wavelength of red light is 6600 Å, then wavelength of first maximum will be: **[Online April 12, 2014]**

(a) 3300Å (b) 4400Å (c) 5500Å (d) 6600Å

75. Abeam of unpolarised light of intensity I_0 is passed through a polaroidAand then through another polaroid B which is oriented so that its principal plane makes an angle of 45° relative to that of A. The intensity of the emergent light is **[2013]**

(a) I_0 (b) $I_0/2$ (c) $I_0/4$ (d) $I_0/8$

76. This question has Statement-1 and Statements-2. Of the four choices given after the Statements, choose the one that best describes the two Statements.

Statement-1 : Out of radio waves and microwaves, the radio waves undergo more diffraction.

Statement-2 : Radio waves have greater frequency compared to microwaves. **[Online April 25, 2013]**

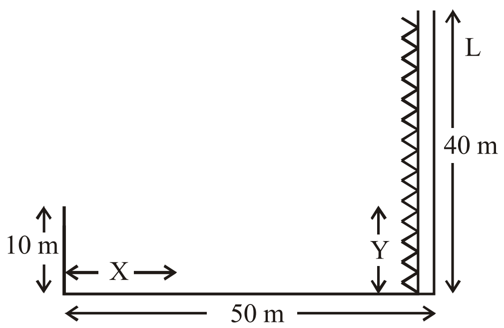
(a) Statement-1 is true, Statement-2 is true and Statement-2 is the correct explanation of Statement-1

(b) Statement-1 is false , Statement-2 is true.

(c) Statement-1 is true, Statement-2 is false.

(d) Statement-1 is true, Statement-2 is true but Statement-2 is not the correct explanation of Statement-1

77. A person lives in a high-rise building on the bank of a river 50 m wide. Across the river is a well lit tower of height 40 m. When the person, who is at a height of 10 m, looks through a polarizer at an appropriate angle at light of the tower reflecting from the river surface, he notes that intensity of light coming from distance X from his building is the least and this corresponds to the light coming from light bulbs at height 'Y' on the tower. The values of X and Y are respectively close to (refractive index of water $\simeq \frac{4}{3}$) **[Online April 9, 2013]**



(a) 25 m, 10 m (b) 13 m, 27 m
(c) 22 m, 13 m (d) 17 m, 20 m

78. The first diffraction minimum due to the single slit diffraction is seen at θ = 30° for a light of wavelength 5000 Å falling perpendicularly on the slit. The width of the slit is **[Online May 12, 2012]**

(a) 2.5×10^{-5} cm (b) 1.25×10^{-5} cm
(c) 10×10^{-5} cm (d) 5×10^{-5} cm

79. Two polaroids have their polarizing directions parallel so that the intensity of a transmitted light is maximum. The angle through which either polaroid must be turned if the intensity is to drop by one-half is **[Online May 7, 2012]**

(a) 135° (b) 90° (c) 120° (d) 180°

80. **Statement - 1:** On viewing the clear blue portion of the sky through a Calcite Crystal, the intensity of transmitted light varies as the crystal is rotated.

Statement - 2: The light coming from the sky is polarized due to scattering of sun light by particles in the atmosphere. The scattering is largest for blue light. **[2011 RS]**

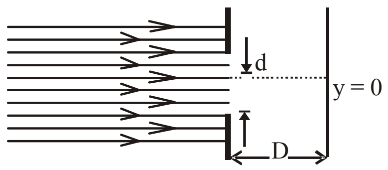
(a) Statement -1 is true, statement-2 is false.

(b) Statement-1 is true, statement-2 is true, statement-2 is the correct explanation of statement-1

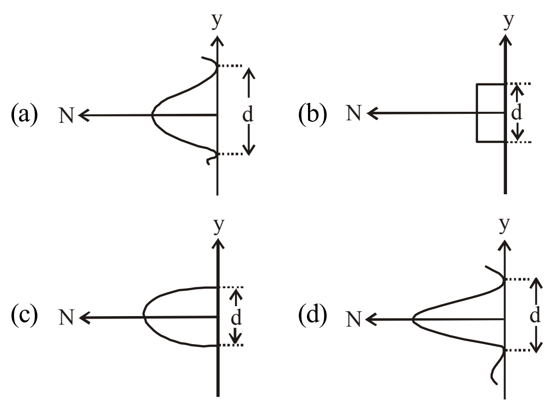
(c) Statement-1 is true, statement-2 is true, statement-2 is not the correct explanation of statement-1

(d) Statement-1 is false, statement-2 is true.

81. In an experiment, electrons are made to pass through a narrow slit of width '*d*' comparable to their de Broglie wavelength. They are detected on a screen at a distance '*D*' from the slit (see figure).



Which of the following graphs can be expected to represent the number of electrons '*N*' detected as a function of the detector position '*y*'(*y* = 0 corresponds to the middle of the slit) **[2008]**



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82. If I_0 is the intensity of the principal maximum in the single slit diffraction pattern, then what will be its intensity when the slit width is doubled? **[2005]**

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

83. When an unpolarized light of intensity I_0 is incident on a polarizing sheet, the intensity of the light which does not get transmitted is **[2005]**

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

84. Two point white dots are 1 mm apart on a black paper. They are viewed by eye of pupil diameter 3 mm. Approximately, what is the maximum distance at which these dots can be resolved by the eye? [Take wavelength of light = 500 nm] **[2005]**

(a) 1m (b) 5m (c) 3m (d) 6m

85. The angle of incidence at which reflected light is totally polarized for reflection from air to glass (refractive index n), is **[2004]**

(a) $\tan^{-1}(1/n)$ (b) $\sin^{-1}(1/n)$

(c) $\sin^{-1}(n)$ (d) $\tan^{-1}(n)$

86. Wavelength of light used in an optical instrument are $\lambda_1 = 4000\,Å$ and $\lambda_2 = 5000\,Å$, then ratio of their respective resolving powers (corresponding to λ_1 and λ_2) is **[2002]**

(a) 16 : 25 (b) 9 : 1 (c) 4 : 5 (d) 5 : 4

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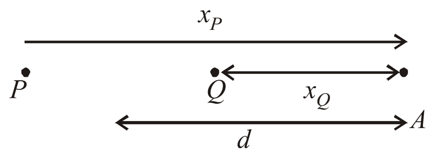
Hints & Solutions

1. **(b)** For (A)



$x_P - x_Q = (d+2.5)-(d-2.5) = 5$ m

Phase difference $\Delta\phi$ due to path difference

$= \frac{2\pi}{\lambda}(\Delta x) = \frac{2\pi}{20}(5) = \frac{\pi}{2}.$

At A, Q is ahead of P by path, as wave emitted by Q reaches before wave emitted by P.

$\therefore$ Total phase difference at A $\frac{\pi}{2} - \frac{\pi}{2} = 0$

(due to P being ahead of Q by 90°)

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

$= I + I + 2\sqrt{I}\sqrt{I}\cos(0) = 4I$

For C,

Path difference, $x_Q - x_P = 5$ m

Phase difference $\Delta\phi$ due to path difference

$= \frac{2\pi}{\lambda}(\Delta x) = \frac{2\pi}{20}(5) = \frac{\pi}{2}$

Total phase difference at C $= \frac{\pi}{2} + \frac{\pi}{2} = \pi$

$I_{net} = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos(\Delta\phi)$

$= I + I + 2\sqrt{I}\sqrt{I}\cos(\pi) = 0$

For B,

Path difference, $x_P - x_Q = 0$

Phase difference, $\Delta\phi = \frac{\pi}{2}$

(due to P being ahead of Q by 90°)

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

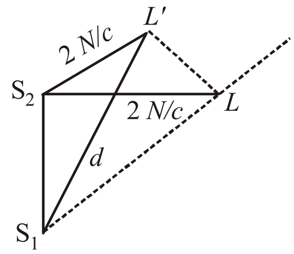
Therefore intensities of radiation at A, B and C will be in the ratio

$I_A : I_B : I_C = 4I : 2I : 0 = 2 : 1 : 0.$

2. **(d)** Initially, $S_2L = 2$ m

$S_1L = \sqrt{2^2 + \left(\frac{3}{2}\right)^2} = \frac{5}{2} = 2.5$ m

Path difference, $\Delta x = S_1L - S_2L = 0.5 \text{ m} = \frac{\lambda}{2}$



When the listner move from L, first maxima will appear if path difference is integral multiple of wavelength.

For example

$\Delta x = n\lambda = 1\lambda$ ($n = 1$ for first maxima)

$\therefore \Delta x = \lambda = S_1L' - S_2L$

$\Rightarrow 1 = d - 2 \Rightarrow d = 3$ m

3. **(c)** The distance traversed by light in a medium of refractive index m 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,

$\Delta = ct = c \times \frac{d}{v}$ [from equation (i)]

$= d\frac{c}{v} = \mu d$ ...(ii) $\left(\because \mu = \frac{c}{v}\right)$

This distance is the equvalent distance in vacuum and is called optical path.

Optical path for first ray which travels a path L_1 through a medium of refractive index $n_1 = n_1L_1$

Optical path for second ray which travels a path L_2 through a medium of refractive index $n_2 = n_2L_2$

Path difference $= n_1L_1 - n_2L_2$

Now, phase difference

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

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4. **(c)** Given amplitude ratio of waves is $\frac{a_1}{a_2} = \frac{3}{1}$

so, $\frac{I_{max}}{I_{min}} - \left(\frac{a_2 + a_1}{a_2 - a_1}\right)^2$

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

5. **(b)** As we know, $\frac{I_{max}}{I_{min}} = \left(\frac{A_1 + A_2}{A_1 - A_2}\right)^2$

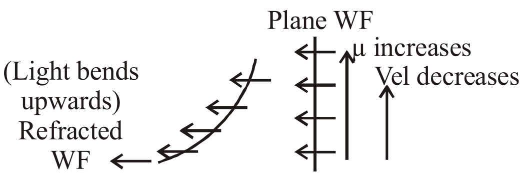
and $\sqrt{\frac{I_1}{I_2}} = \frac{A_1}{A_2}$

$$\frac{I_{max}}{I_{min}} = 16 \Rightarrow \frac{A_{max}}{A_{min}} = 4 \Rightarrow \frac{A_1 + A_2}{A_1 - A_2} = \frac{4}{1}$$

Using componendo and dividendo.

$$\frac{A_1}{A_2} = \frac{5}{3} \Rightarrow \frac{I_1}{I_2} = \left(\frac{5}{3}\right)^2 = \frac{25}{9}$$

6. **(b)**



7. **(c)**
8. **(d)** Intensity ∝ (amplitude)²

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

$\Rightarrow a_1 = 4;\ a_2 = 3$

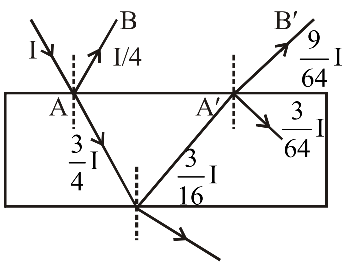
Therefore the ratio of intensities of bright and dark parts

$$\frac{I_{Bright}}{I_{Dark}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(4+3)^2}{(4-3)^2} = \frac{49}{1}$$

9. **(d)** $\frac{\text{(Maximum intensity) coherent interference}}{\text{(Maximum intensity) in coherent interference}}$

$$= \frac{n^2 I_0}{n I_0} = n$$

10. **(a)**



From figure $I_1 = \frac{I}{4}$ and $I_2 = \frac{9I}{64}$

$$\Rightarrow \frac{I_2}{I_1} = \frac{9}{16}$$

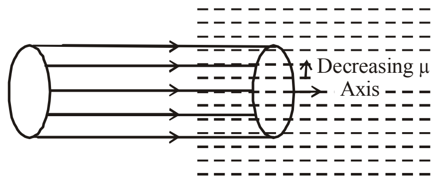
By using $\frac{I_{max}}{I_{min}} = \left(\frac{\sqrt{\frac{I_2}{I_1}} + 1}{\sqrt{\frac{I_2}{I_1}} - 1}\right)^2$

$$= \left(\frac{\sqrt{\frac{9}{16}} + 1}{\sqrt{\frac{9}{16}} - 1}\right)^2 = \frac{49}{1}$$

11. **(c)** $\Delta x = \frac{\lambda}{(2\alpha)}$

12. **(b)** A phase change of π rad appears when the ray reflects at the glass-air interface. As a result, there will be a destructive interference at the centre. So, the centre of the interference pattern is dark.

13. **(b)** When light beam is moving and as it enters the medium, the refractive index will decrease from the axis towards the periphery of the beam.
Therefore, the beam will conver less distance as one move from the axis to the periphery and hence the beam will converge.



14. **(d)** Initially the parallel beam is cylindrical. Therefore, the wavefront will be planar.

15. **(a)** The speed of light (v) in a medium of refractive index (μ) is given by

$\mu = \frac{c}{v}$, where c is the speed of light in vacuum

$$\therefore v = \frac{c}{\mu} = \frac{c}{\mu_0 + \mu_2(I)}$$

As I is decreasing with increasing radius, it is maximum on the axis of the beam. Therefore, v is minimum on the axis of the beam.

16. **(d)** To demonstrate the phenomenon of interference we require two sources of light which emit radiation of same frequency and having a definite phase relationship (a phase relationship that does not change with time)

17. **(9)**
In young's double slit experiment, intensity at a point is given by

$$I = I_0 \cos^2 \frac{\phi}{2} \quad \text{...(i)}$$

where, ϕ = phase difference,

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Using phase difference, $\phi = \frac{2\pi}{\lambda} \times$ path difference

For path difference λ, phase difference $\phi_1 = 2\pi$

For path difference, $\frac{\lambda}{6}$, phase difference $\phi_2 = \frac{\pi}{3}$

Using equation (i),

$$\frac{I_1}{I_2} = \frac{\cos^2\left(\frac{\phi_1}{2}\right)}{\cos^2\left(\frac{\phi_2}{2}\right)} = \frac{\cos^2\left(\frac{2\pi}{2}\right)}{\cos^2\left(\frac{\pi}{3}\right)}$$

$$\Rightarrow \frac{K}{I_2} = \frac{1}{\frac{3}{4}} = \frac{4}{3} \Rightarrow I_2 = \frac{3K}{4} = \frac{9K}{12}$$

$\therefore n = 9.$

18. **(b)** Given : Wavelength of light, $\lambda = 500$ nm
Distance between the slits, $d = 0.05$ mm
Angular width of the fringe formed,

$$\theta = \frac{\lambda}{d} = \frac{500 \times 10^{-9}}{0.05 \times 10^{-3}} = 0.01 \text{ rad} = 0.57°.$$

19. **(a)** Path difference, $\Delta P = d\sin\theta = d\theta$
d = distance between slits = 1 mm = 10^{-3} mm
D = distance between the slits and screen = 100 cm = 1 m
y = distance between central bright fringe and observed fringe = 1.27 mm

$$\therefore \Delta P = \frac{dy}{D} = \frac{10^{-3} \times 1.270 \text{ mm}}{1 \text{ m}} = 1.27 \ \mu\text{m}$$

20. **(d)** Let n_1 fringes are visible with light of wavelength λ_1 and n_2 with light of wavelength λ_2. Then

$$\beta = \frac{n_1 D\lambda_1}{d} = \frac{n_2 D\lambda_2}{d} \qquad \left(\because \beta = \frac{n\lambda D}{d}\right)$$

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

$$\Rightarrow n_2 = \frac{700}{400} \times 16 = 28$$

21. **(750)** Fringe width, $\beta = \frac{\lambda D}{d}$ where, λ = wavelength, D = distance of screen from slits, d = distance between slits

ATQ

$$15 \times \frac{\lambda_1 D}{d} = 10 \times \frac{\lambda_2 D}{d}$$

$\Rightarrow \quad 15\lambda_1 = 10\lambda_2$

$\Rightarrow \quad \lambda_2 = 1.5\lambda_1 15\lambda_1 = 1.5 \times 500$ nm

$\Rightarrow \quad \lambda_2 = 750$ nm

22. **(a)** Given, Path difference, $\Delta x = \frac{\lambda}{8}$

Phase differences, $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$

$$= \frac{2\pi}{\lambda} \times \frac{\lambda}{8} = \frac{\pi}{4}$$

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

$$\Rightarrow \frac{I}{I_0} = \cos^2\left(\frac{\frac{\pi}{4}}{2}\right) = \cos^2\left(\frac{\pi}{8}\right)$$

$$\Rightarrow \frac{I}{I_0} = 0.853$$

23. **(c)** Given, distance between screen and slits, $D = 1.5$ m
Seperation between slits, d = 0.15 mm
Wavelength of source of light, $\lambda = 589$ nm
Fringe-width,

$$w = \frac{D}{d}\lambda = \frac{1.5}{0.15 \times 10^{-3}} \times 589 \times 10^{-9} \, m$$

$= 589 \times 10^{-2}$ mm $= 5.89$ mm ≈ 5.9 mm

24. **(c)** Given, $\Delta = \beta$

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

$\therefore \quad t = \frac{\lambda}{(\mu - 1)}$

25. **(Bonus)** Shift = nβ (given)

$$\therefore \ D\frac{(\mu - 1)t}{a} = \frac{n\lambda D}{a} \quad \left[\because \text{Shift} = \frac{D(\mu - 1)t}{a}\right]$$

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

26. **(b)** Given, path difference, $\Delta x = \frac{\lambda}{8}$

Phase difference ($\Delta\phi$) is given by

$$\Delta\phi = \frac{2\pi}{\lambda}(\Delta x)$$

$$\Delta\phi = \frac{(2\pi)}{\lambda}\frac{\lambda}{8} = \frac{\pi}{4}$$

For two sources in different phases,

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$$I = I_0 \cos^2\left(\frac{\pi}{8}\right)$$

$$\frac{I}{I_0} = \cos^2\left(\frac{\pi}{8}\right)$$

$$= \frac{1+\cos\frac{\pi}{4}}{2} = \frac{1+\frac{1}{\sqrt{2}}}{2} = 0.85$$

27. **(a)** Path difference $= d \sin\theta \approx d\theta$

$$= 0.1 \times \frac{1}{40} \text{ mm} = 2500 \text{nm}$$

For bright fringe, path difference must be integral multiple of λ.

$\therefore 2500 = n\lambda_1 = m\lambda_2$

$\therefore \lambda_1 = 625$ (for n = 4), $\lambda_2 = 500$ (for m = 5)

28. **(a)** Here, $x_1 = 2d$ and $x_2 = \sqrt{5d}$

For, first minima, $\Delta x = \frac{\lambda}{2}$

$$\therefore \Delta x = x_2 - x_1 = \sqrt{5}d - 2d = \frac{\lambda}{2}$$

$$\Rightarrow d = \frac{\lambda}{2\left(\sqrt{5}-2\right)}$$

29. **(d)** For 'n' number of maximas

$d \sin\theta = n\lambda$

$0.32 \times 10^{-3} \sin 30° = n \times 500 \times 10^{-9}$

$$\therefore \quad n = \frac{0.32\times10^{-3}}{500\times10^{-9}} \times \frac{1}{2} = 320$$

Hence total no. of maximas observed in angular range – $30° \le \theta \le 30°$

$= 320 + 1 + 320 = 641$

30. **(d)** For common maxima, $n_1\lambda_1 = n_2\lambda_2$

$$\Rightarrow \frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{520\times10^{-9}}{650\times10^{-9}} = \frac{4}{5}$$

For λ_1

$$y = \frac{n_1\lambda_1 D}{d}, \; \lambda_1 = 650 \text{ nm}$$

$$y = \frac{4\times650\times10^{-9}\times1.5}{0.5\times10^{-3}} \quad \text{or,} \quad y = 7.8 \text{ mm}$$

31. **(c)** $2I_0 = 4I_0 \cos^2\left(\frac{\Delta\phi}{2}\right)$ here, $\Delta\phi = \frac{\pi}{2}$

But, $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ so, $\Delta x = \frac{\lambda}{4}$

$$\frac{dy}{D} = \frac{\lambda}{4} \quad \text{....(i)}$$

$$\frac{\lambda D}{d} = \beta \quad \text{....(ii)}$$

Multiplying equation (i) and (ii) we get,

$$y = \frac{\beta}{4}$$

32. **(c)**

33. **(b)** Given $t = 1.8 \times 10^{-6}$m

$\mu = 1.6$

n = 2 (from figure)

Applying formula $(\mu - 1)\,t = n\lambda$

$(1.6 - 1) \times 1.8 \times 10^{-6} = 2\lambda$

$$\text{or, } \lambda = \frac{1.8\times10^{-6}\times0.6}{2}$$

$= 540$ nm

34. **(d)** It will be concentric circles.

35. **(d)**

36. **(c)**

37. **(c)** Fringe width $B = \frac{D}{d}\lambda$

And number of fringes observed in the field of view is obtained by $\frac{d}{\lambda}$

38. **(d)** Let a, be the amplitude of light from first slit and a_2 be the amplitude of light from second slit.

$a_1 = a$, Then $a_2 = 2a$

Intensity $I \propto$ (amplitude)^2

$\therefore \quad I_1 = a_1^2 = a^2$

$I_2 = a_2^2 = 4a^2 = 4I$

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

$= I_1 + I_2 + 2\sqrt{I_1I_2}\cos\phi$

$I_r = I_1 + 4I_1 + 2\sqrt{4I_1^2}\cos\phi$

$\Rightarrow \quad I_r = 5I_1 + 4I_1 \cos\phi \quad \quad \ldots(1)$

Now, $I_{max} = (a_1 + a_2)^2 = (a + 2a)^2 = 9a^2$

$$I_{max} = 9I_1 \Rightarrow I_1 = \frac{I_{max}}{9}$$

Substituting in equation (1)

$$I_r = \frac{5I_{max}}{9} + \frac{4I_{max}}{9}\cos\phi$$

$$I_r = \frac{I_{max}}{9}[5 + 4\cos\phi]$$

$$I_r = \frac{I_{max}}{9}\left[5 + 8\cos^2\frac{\phi}{2} - 4\right]$$

$$I_r = \frac{I_{max}}{9}\left[1 + 8\cos^2\frac{\phi}{2}\right]$$

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39. **(c)** We know that,

$$\frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{\frac{\omega_1}{\omega_2}}+1\right)^2}{\left(\sqrt{\frac{\omega_1}{\omega_2}}-1\right)^2}$$

I_{max} and I_{min} are maximum and minium intensity

ω_1 and ω_2 are widths of two slits

$$\therefore \frac{I_{max}}{I_{min}} = \frac{\left(\sqrt{\frac{1}{25}}+1\right)^2}{\left(\sqrt{\frac{1}{25}}-1\right)^2} \quad \left(\frac{\omega_1}{\omega_2} = \frac{1}{25}\text{given}\right)$$

On solving we get,

$$\frac{I_{max}}{I_{min}} = \frac{\frac{36}{25}}{\frac{16}{25}} = \frac{9}{4} = 9:4$$

40. **(b)** As $\sin\theta = \frac{n\lambda}{d}$ and $\sin\theta$ cannot be $\not>1$

$$\therefore 1 = \frac{n\lambda}{1.8\lambda}$$

or $n = 1.8$

Hence maximum number of possible interference maximas, 0, ± 1 i.e. 3

41. **(c)** Shift $= \frac{\beta(\mu-1)}{\lambda}t_1 - \frac{\beta(\mu-1)}{\lambda}t_2$

$$= \frac{\beta(\mu-1)}{\lambda}(t_1 - t_2)$$

42. **(a)** Path difference at P $\Delta x_1 = 0$

$\therefore$ Phase difference at P will be

$$\Delta\phi_1 = \frac{2\pi}{\lambda}\Delta x_1$$

$$= \frac{2\pi}{\lambda}\times 0$$

$$= 0°$$

Resultant Intensity at P

$$I_1 = I_0 + I_0 + 2I_0\cos 0° = 4I_0$$

Path difference at Q

$$\Delta x_2 = \frac{\lambda}{4}$$

$\therefore$ Phase difference at Q

$$\Delta = \frac{2\pi}{\lambda}\cdot\frac{\lambda}{4} = \left(\frac{\pi}{2}\right)$$

Resultant intensity at Q.

$$I_2 = I_0 + I_0 + 2I_0\cos\frac{\pi}{2} = 2I_0$$

Thus, $\frac{I_1}{I_2} = \frac{4I_0}{2I_0} = \frac{2}{1}$

43. **(a)** For coherent sources, intensity at mid point

$I_1 \propto (a+a)^2$

$\Rightarrow I_1 \propto (2a)^2$

For incoherent sources, intensity of mid point is

$I_2 \propto 2a^2$

$$\therefore \frac{I_1}{I_2} = \frac{2}{1}$$

44. **(b)** Let λ be the wavelength of unknown light. Third bright fringe of known light coincides with the 4th bright fringe of the unknown light.

$$\therefore \frac{3\lambda_1 D}{d} = \frac{4\lambda D}{d}$$

$$\therefore \frac{3(590)D}{d} = \frac{4\lambda D}{d}$$

$$\Rightarrow \lambda = \frac{3}{4}\times 590 = 442.5\text{ nm}$$

45. **(a)** For path difference of λ, the phase difference is 2π

For path difference of $\frac{\lambda}{6}$, the phase difference is

$$\frac{2\pi\times\lambda/6}{\lambda} = \frac{\pi}{3}$$

Resultant intensity

$$I = I_1 + I_2 + 2\sqrt{I_1}\sqrt{I_2}\cos\frac{\pi}{3}$$

$$\therefore I = I_1 + I_2 + \sqrt{I_1}\sqrt{I_2}$$

For two identical source, $I_1 = I_2 = I'$ (say)

then $I = 3I'$

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

Maximum resultant intensity,

$$= \left(\sqrt{I'}+\sqrt{I'}\right)^2 = \left(2\sqrt{I'}\right)^2 = 4I'$$

$$\therefore \frac{I}{I_{max}} = \frac{3}{4}$$

ALTERNATE SOLUTION

The intensity of light at any point of the screen where the phase difference due to light coming from the two slits is ϕ is given by

$$I = I_o\cos^2\left(\frac{\phi}{2}\right)$$

Where I_0 is the maximum intensity.

NOTE This formula is applicable when $I_1 = I_2$.

Phase difference $\phi = \frac{2\pi}{\lambda}\times\frac{\lambda}{6} = \pi/3$

$$\therefore \frac{I}{I_0} = \cos^2\frac{\pi}{6} = \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4}$$

46. **(d)** The light passing through the slits interfere and produce dark and bright band one screen. The shape of interference fringes formed on a screen in case of a monochromatic source is a straight line.

47. **(b)** For constructive interference path difference (As $\sin\theta \le 1$)

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

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Given $d = 2\lambda$

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

$n = 0, 1, -1, 2, -2$ hence five maxima are possible.

48. (d) Given :

Intensity, $I_0 = 3.3\ \text{Wm}^{-2}$

Area, $A = 3 \times 10^{-4}\ \text{m}^2$

Angular speed, $\omega = 31.4$ rad/s

Average energy $= I_0 A < \cos^2\theta >$

$\because < \cos^2\theta > = \frac{1}{2}$ per revolution

$\therefore$ Average energy $= \frac{(3.3)(3\times10^{-4})}{2} \simeq 5\times10^{-4}$ J

49. (198)

For obtaining secondary minima at a point path difference should be integral multiple of wavelength

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

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

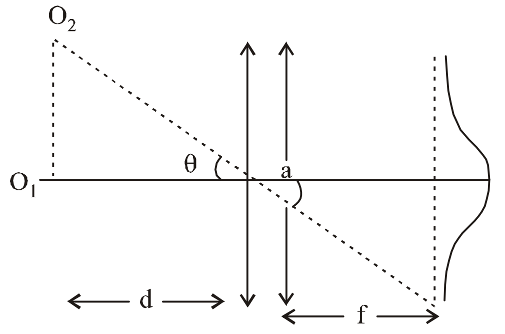
For n to be maximum $\sin\theta = 1$

$$n = \frac{d}{\lambda} = \frac{6\times10^{-5}}{6\times10^{-7}} = 100$$

Total number of minima on one side = 99

Total number of minima = 198.

50. (a)



Smallest angular separation between two distant objects here moon and earth,

$$\theta = 1.22\frac{\lambda}{a}$$

a = aperture diameter of telescope

Distance $O_1O_2 = (\theta)d$

Minimum separation between objects on the surface of moon,

$$= \left(1.22\frac{\lambda}{a}\right)d$$

$$= \frac{(1.22)(5500\times10^{-10})\times4\times10^5\times10^3}{5}$$

$= 5368 \times 10^{-2}$ m $= 53.68$ m ≈ 60 m

51. (b) According to question, the intensity of light coming out of the analyser is just 10% of the original intensity (I_0)

Using, $I = I_0\cos^2\theta$

$$\Rightarrow \frac{I_0}{10} = I_0\cos^2\theta \Rightarrow \frac{1}{10} = \cos^2\theta$$

$$\Rightarrow \cos\theta = \frac{1}{\sqrt{10}} = 0.316 \Rightarrow \theta \approx 71.6°$$

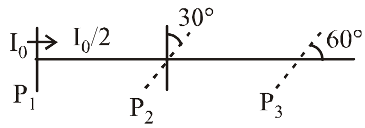
Therefore, the angle by which the analyser need to be rotated further to reduced the output intensity to be zero

$\phi = 90° - \theta = 90° - 71.6° = 18.4°$

52. (a) $x = \frac{1.22\lambda}{2\mu\sin\theta}$

$$= \frac{1.22\times5000}{2\times1.25} = 0.24\ \mu\text{m}$$

53. (c) $I = \left(\frac{I_0}{2}\right)\cos^2 30°\cos^2 60°$



$$= \frac{I_0}{2}\times\frac{3}{4}\times\frac{1}{4}$$

$$\therefore \frac{I_0}{I} = \frac{32}{3} = 10.67$$

54. (c) $\theta = \frac{1.22\lambda}{d} = \frac{1.22\times600\times10^{-9}}{250\times10^{-2}}$

$= 3.0 \times 10^{-7}$ rad

55. (a) $\theta = \frac{1.22\lambda}{d} = \frac{1.22\times500\times10^{-9}}{2} = 305 \times 10^{-9}$ rad.

56. (b)

57. (b) According to Brewster's law, refractive index of material (μ) is equal to tangent of polarising angle

$$\because \tan i_b = \mu = \frac{1.5}{\mu}$$

$$\frac{1}{\mu} < \frac{1.5}{\sqrt{\mu^2+(1.5)^2}} \quad (\because \sin i_c < \sin i_b)$$

$$\therefore \sin i_b = \frac{1.5}{\sqrt{\mu^2+(1.5)^2}}$$

or, $\sqrt{\mu^2+(1.5)^2} < 1.5\times\mu$

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$\Rightarrow \mu^2 + (1.5)^2 < (\mu \times 1.5)^2$

$\Rightarrow \mu < \frac{3}{\sqrt{5}}$ i.e. minimum value of μ should be $\frac{3}{\sqrt{5}}$

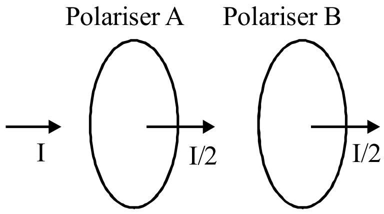
58. **(a)** Angular width of central maxima = $\frac{2\lambda}{d}$

or, $\lambda = \frac{d}{2}$; Fringe width, $\beta = \frac{\lambda \times D}{d'}$

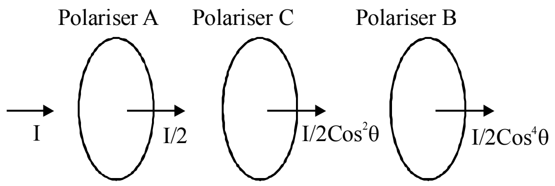
$$10^{-2} = \frac{d}{2} \times \frac{50 \times 10^{-2}}{d'} = \frac{10^{-6} \times 50 \times 10^{-2}}{2 \times d'}$$

Therefore, slit separation distance, d' = 25μm

59. **(c)** Axis of transmission of A & B are parallel.



After introducing polariser C between A and B,



$$\frac{I}{2}\cos^4\theta = \frac{I}{8} \Rightarrow \cos^4\theta = \frac{1}{4}$$

$$\Rightarrow \cos\theta = \frac{1}{\sqrt{2}} \text{ or, } \theta = 45°$$

60. **(a)** If angular position of 2nd maxima from central maxima is θ then

$$\sin\theta = \frac{(2n-1)\lambda}{2a} = \frac{3\lambda}{20} = \frac{3 \times 550 \times 10^{-9}}{2 \times 22 \times 10^{-7}}$$

$\therefore \quad \theta \simeq \frac{\pi}{8}$ rad

61. **(a)** Polariser A and B have same alignment of transmission axis.

Lets assume polariser c is introduced at θ angle

$$\frac{1}{2}\cos^2\theta \times \cos^2\theta = \frac{1}{3}$$

or, $\quad \cos^4\theta = \frac{2}{3} \Rightarrow \cos\theta = \left(\frac{2}{3}\right)^{1/4}$

62. **(a)**

63. **(a)** Use relativistic doppler's effect as velocity of observer is not small as compared to light

$f = f_0\sqrt{\frac{c+v}{c+v}}$; $\quad V$ = relative speed of approach

f_0 = 10 GHz

$$f = 10\sqrt{\frac{c+\frac{c}{2}}{c-\frac{c}{2}}} = 10\sqrt{3} = 17.3 \text{ GHz}$$

64. **(b)** a = 0.1 mm = 10^{-4} cm,

$\lambda = 6000 \times 10^{-10}$ cm $= 6 \times 10^{-7}$ cm, D = 0.5 m

for 3rd dark band, a sin θ = 3 λ

or $\quad \sin\theta = \frac{3\lambda}{a} = \frac{x}{D}$

The distance of the third dark band from the central bright band

$$x = \frac{3\lambda D}{a} = \frac{3 \times 6 \times 10^{-7} \times 0.5}{10^{-4}} = 9 \text{ mm}$$

65. **(b)** For secondary minima,

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

Distance of nth secondary minima x = D sin θ

or $\quad \sin\theta_1 = \frac{x_1}{D}$

$\sin\theta_1 = \frac{2\lambda}{b}$

n = 4

$\sin\theta_2 = \frac{4\lambda}{b} = \frac{x_2}{D}$

$x_2 - x_1 = \frac{4\lambda}{b} - \frac{2\lambda}{b} = \frac{2\lambda}{b}$

$3 = \frac{2\lambda}{b} \Rightarrow b = \frac{2\lambda}{3}$ ..... (i)

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

$= \frac{2\lambda}{\frac{2\lambda}{3}} = 3$ cm.

.. from eq. (i)

66. **(a)** Given geometrical spread = a

Diffraction spread $= \frac{\lambda}{a} \times L = \frac{\lambda L}{a}$

The sum $b = a + \frac{\lambda L}{a}$

For b to be minimum

$\frac{db}{da} = 0 \qquad \frac{d}{da}\left(a + \frac{\lambda L}{a}\right) = 0$

$a = \sqrt{\lambda L}$

$b \min = \sqrt{\lambda L} + \sqrt{\lambda L} = 2\sqrt{\lambda L} = \sqrt{4\lambda L}$

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67. **(a)** We know that $\Delta\theta = \frac{0.61\lambda}{4} = \frac{l}{R}$

The minimum distance between them

$$l = \frac{R}{9} 0.61 \times \lambda = \frac{9.46 \times 10^{15} \times 10 \times 0.61 \times 600 \times 10^{-9}}{0.3}$$

$= 1.15 \times 10^{11}$ m

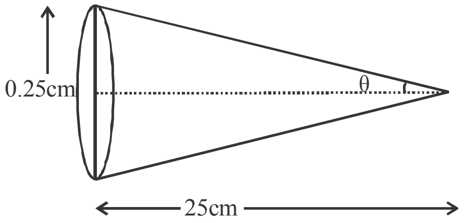
$\Rightarrow 1.115 \times 10^{8}$ km.

68. **(c)** Given D = 1.0m, wavelength of monochromatic light λ = 600 nm.

$$d : D\theta = 1 \times \frac{\pi}{180} \times \frac{1}{60}$$

$$d_0 = 2 \times 10^{-3} = 2\,\text{mm}$$

69. **(d)** $\sin\theta = \frac{0.25}{25} = \frac{1}{100}$



Resolving power $= \frac{1.22\lambda}{2\mu\sin\theta} = 30\ \mu$m.

70. **(a)** When unpolarised light is incident at Brewster's angle then reflected light is completely polarized and the intensity of the reflected light is less than half of the incident light.

71. **(d)** According to malus law, intensity of emerging beam is given by,

$I = I_0 \cos^2\theta$

Now, $I_{A'} = I_A \cos^2 30°$

$I_{B'} = I_B \cos^2 60°$

As $I_{A'} = I_{B'}$

$\Rightarrow \quad I_A \times \frac{3}{4} = I_B \times \frac{1}{4};\ \frac{I_A}{I_B} = \frac{1}{3}$

72. **(c)** Resolving power of microscope,

$$\text{R.P.} = \frac{2n\sin\theta}{\lambda}$$

λ = Wavelength of light used to illuminate the object

n = Refractive index of the medium between object and objective

θ = Angle

73. **(c)** Here, $\sin\theta_{ic} / \sin\theta_{iB} = 1.28$

As we know,

$$\mu = \frac{\sin\theta_{iB}}{\sin\left(\frac{\pi}{2} - \theta_{iB}\right)}$$

where, θ_{iB} is Brewster's angle of incidence,

And, $\mu = \frac{1}{\sin\theta_{ic}}$

On solving we get, relative refractive index of the two media.

74. **(b)** In a single slit experiment,

For diffraction maxima,

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

and for diffraction minima,

$a\sin\theta = n\lambda$

According to question,

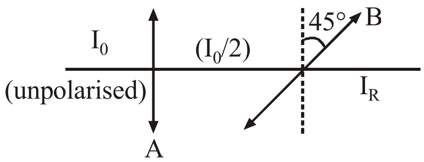
$$(2 \times 1 + 1)\frac{\lambda}{2} = 1 \times 6600$$

$$(\because \lambda_R = 6600\text{Å})$$

$$\lambda = \frac{6600 \times 2}{3}$$

$\lambda = 4400$Å

75. **(c)** Relation between intensities



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

76. **(c)** Wavelength of radio waves is greater than microwaves hence frequency of radio waves is less than microwaves.

The degree of diffraction is greater whose wavelength is greater.

77. **(b)**

78. **(c)** For first minimum,

$d\sin\theta = \lambda$

$$\Rightarrow \quad d = \frac{\lambda}{\sin\theta} = \frac{5000 \times 10^{-8}\,\text{cm}}{\sin 30°}$$

$$= \frac{5000 \times 10^{-8}\,\text{cm}}{1/2} = 10 \times 10^{-5}\,\text{cm}$$

79. **(a)** For $I = \frac{I_0}{2}$ and $I = I_0\cos^2\theta = \frac{I_0}{2}$

$\therefore \theta = 45°$

Therefore the angle through which either polaroids turned is 135° (= 180° – 45°)

80. **(b)** When viewed through a polaroid which is rotated then the light from a clear blue portion of the sky shows a rise and fall of intensity. The light coming from the sky is polarised due to scattering of sunlight by particles in the atmosphere.

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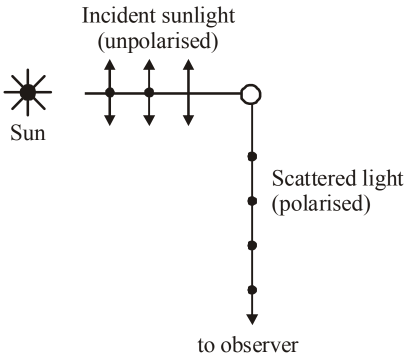

81. **(d)** The electron beam will be diffracted and the maxima is obtained at $y = 0$.
Also, the diffraction pattern, should be wider than the slit width.

82. **(a)** $I = I_0\left(\frac{\sin\phi}{\phi}\right)^2$ and $\phi = \frac{\pi}{\lambda}(b\sin\theta)$

When the slit width is doubled, the amplitude of the wave at the centre of the screen is doubled, so the intensity at the centre is increased by a factor 4.

83. **(b)** From the law of Malus, $I = I_0\cos^2\theta$
When an unpolarised light is converted into plane polarised light by passing through polariod, its intensity become hafl.

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

$\Rightarrow$ Intensity of untransmitted light

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

84. **(b)** $\frac{y}{D} \geq 1.22\frac{\lambda}{d}$

$$\Rightarrow D \leq \frac{yd}{(1.22)\lambda} = \frac{10^{-3}\times 3\times 10^{-3}}{(1.22)\times 5\times 10^{-7}} = \frac{30}{6.1} \approx 5\text{m}$$

$\therefore D_{max} = 5\text{m}$

85. **(d)** From the Brewster's law, angle of incidence for total polarization is given by $\tan\theta = n$
$\Rightarrow \theta = \tan^{-1} n$
Where n is the refractive index of the glass.

86. **(d)** The resolving power of an optical instrument is inversely proportional to the wavelength of light used.

$$\frac{(R.P)_1}{(R.P)_2} = \frac{\lambda_2}{\lambda_1} = \frac{5}{4}$$

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