Previous Years' CBSE Board Questions

10.2 Huygens Principle

VSA (1 mark)

1. State Huygens principle of diffraction of light. *(AI 2011C)*

10.3 Refraction and Reflection of Plane Waves using Huygens Principle

SA II (3 marks)

2. Define the term wavefront. Using Huygens wave theory, verify the law of reflection. *(Delhi 2019)*

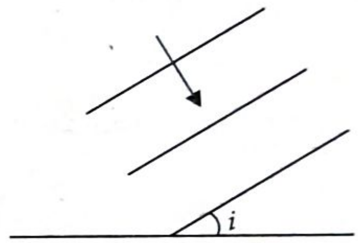
3. Define the term, "refractive index" of a medium. Verify Snell's law of refraction when a plane wavefront is propagating from a denser to a rarer medium. *(Delhi 2019)*

4. Define the term wavefront. State Huygen's principle. Consider a plane wavefront incident on a thin convex lens. Draw a proper diagram to show how the incident wavefront traverses through the lens and after refraction focusses on the focal point of the lens, giving the shape of the emergent wavefront. *(AI 2016)*

5. Explain the following, giving reasons:
   (i) When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency.
   (ii) When light travels from a rarer to a denser medium, the speed decreases. Does this decrease in speed imply a reduction in the energy carried by the wave ?
   (iii) In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determines the intensity in the photon picture of light? *(AI 2016)*

6. Use Huygens principle to show how a plane wavefront propagates from a denser to rarer medium. Hence verify Snell's law of refraction. *(AI 2015)*

7. A plane wavefront propagating in a medium of refractive index 'μ_1' is incident on a plane surface making the angle of incidence i as shown in the figure. It enters into a medium of refraction of refractive index 'μ_2' ($\mu_2 > \mu_1$). Use Huygens' construction of secondary wavelets to trace the propagation of the refracted wavefront. Hence verify Snell's law of refraction. *(Foreign 2015)*



8. Use Huygen's principle to verify the laws of refraction. *(Delhi 2011)*

9. Using Huygens' principle draw a diagram showing how a plane wave gets refracted when it is incident on the surface separating a rarer medium from a denser medium. Hence verify Snell's law of refraction. *(AI 2011C)*

LA (5 marks)

10. Define a wavefront. Using Huygen's principle verify the laws of reflection at a plane surface. *(2018)*

11. Define wavefront. Use Huygen's principle to verify the laws of refraction. *(3/5, AI 2017)*

12. (a) Define a wavefront. How is it different from a ray?
    (b) Depict the shape of a wavefront in each of the following cases.
    (i) Light diverging from point source.
    (ii) Light emerging out of a convex lens when a point source is placed at its focus.

(iii) Using Huygen's construction of secondary wavelets, draw a diagram showing the passage of a plane wavefront from a denser into a rarer medium. *(AI 2015C)*

13. (a) State Huygen's principle. Using this principle draw a diagram to show how a plane wavefront incident at the interface of the two media gets refracted when it propagates from a rarer to a denser medium. Hence verify Snell's law of refraction.
(b) When monochromatic light travels from a rarer to a denser medium, explain the following, giving reasons:
(i) Is the frequency of reflected and refracted light same as the frequency of incident light?
(ii) Does the decrease in speed imply a reduction in the energy carried by light wave? *(Delhi 2013)*

14. (a) Use Huygen's geometrical construction to show how a plane wave-front at $t = 0$ propagates and produces a wave-front at a later time.
(b) Verify, using Huygen's principle, Snell's law of refraction of a plane wave propagating from a denser to a rarer medium.
(c) When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency. Explain why. *(Delhi 2013C)*

15. Define a wavefront. Use Huygens' geometrical construction to show the propagation of a plane wavefront from a rarer medium to a denser medium undergoing refraction. Hence derive Snell's law of refraction.

(Foreign 2012)

16. (a) Use Huygens' geometrical construction to show the behaviour of a plane wavefront
(i) passing through a biconvex lens.
(ii) reflecting by a concave mirror.
(b) When monochromatic light is incident on a surface separating two media, why does the refracted light have the same frequency as that of the incident light? *(Foreign 2012)*

17. (i) A plane wavefront approaches a plane surface separating two media. If medium 'one' is optically denser and medium 'two' is optically rarer, using Huygens' principle, explain and show how a refracted wavefront is constructed.
(ii) Hence verify Snell's law.
(iii) When a light wave travels from rarer to denser medium, the speed decreases. Does it imply reduction in its energy? Explain. *(Foreign 2011)*

18. Using Huygen's construction, draw a figure showing the propagation of a plane wave reflecting at the interface of the two media. Show that the angle of incidence is equal to the angle of reflection. *(Delhi 2010)*

10.4 Coherent and Incoherent Addition of Waves

VSA (1 mark)

19. Define the term 'coherent sources' which are required to produce interference pattern in Young's double slit experiment. *(Delhi 2014C)*

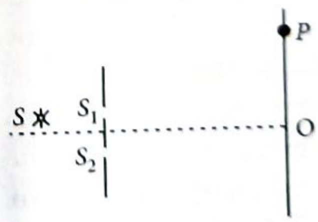
SA I (2 marks)

20. (a) Write the conditions under which light sources can be said to be coherent.
(b) Why is it necessary to have coherent sources in order to produce an interference pattern? *(AI 2013C)*

10.5 Interference of Light Waves and Young's Experiment

SA I (2 marks)

21. The figure shows a modified Young's double slit experimental set-up. Here $SS_2 - SS_1 = \lambda/4$.



(a) Write the condition for constructive interference.
(b) Obtain an expression for the fringe width. *(AI 2019)*

22. For a single slit of width 'a', the first minimum of the interference pattern of a monochromatic light of wavelength λ occurs at an angle of $\frac{\lambda}{a}$. At the same angle of $\frac{\lambda}{a}$, we get a maximum for two narrow slits separated by a distance 'a'. Explain. *(Delhi 2014)*

23. (a) State two conditions required for obtaining coherent sources.
(b) In Young's arrangement to produce interference pattern, show that dark and bright fringes appearing on the screen are equally spaced. *(Delhi 2012C)*

24. Laser light of wavelength 640 nm incident on a pair of slits produces an interference pattern in which the bright fringes are separated by 7.2 mm. Calculate the wavelength of another source of light which produces interference fringes separated by 8.1 mm using same arrangement. Also find the minimum value of the order (n) of bright fringe of shorter wavelength which coincides with that of the longer wavelength. *(AI 2012 C)*

25. Two slits are made one millimetre apart and the screen is placed one metre away. What is the fringe separation when blue-green light of wavelength 500 nm is used? *(Delhi 2011C)*

26. Laser light of wavelength 630 nm incident on a pair of slits produces an interference pattern in which the bright fringes are separated by 7.2 mm. Calculate the wavelength of another source of laser light which produces interference fringes separated by 8.1 mm using same pair of slits. *(AI 2011C)*

SA II (3 marks)

27. (a) If one of two identical slits producing interference in Young's experiment is covered with glass, so that the light intensity passing through it is reduced to 50%, find the ratio of the maximum and minimum intensity of the fringe in the interference pattern.
(b) What kind of fringes do you expect to observe if white light is used instead of monochromatic light? *(2018)*

28. Answer the following questions :
(a) In a double slit experiment using light of wavelength 600 nm, the angular width of the fringe formed on a distant screen is 0.1°. Find the spacing between the two slits.
(b) Light of wavelength 500 Å propagating in air gets partly reflected from the surface of water. How will the wavelengths and frequencies of the reflected and refracted light be affected? *(Delhi 2015)*

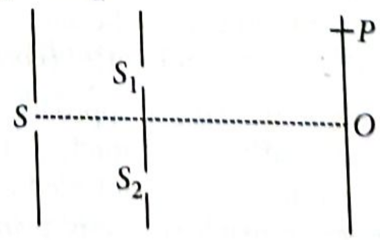
29. Why cannot two independent monochromatic sources produce sustained interference pattern? Deduce, with the help of Young's arrangement to produce interference pattern, an expression for the fringe width. *(Foreign 2015)*

30. (a) The ratio of the widths of two slits in Young's double slit experiment is 4 : 1. Evaluate the ratio of intensities at maxima and minima in the interference pattern.
(b) Does the appearance of bright and dark fringes in the interference pattern violate, in any way, conservation of energy? Explain. *(AI 2015C)*

31. (a) Two monochromatic waves emanating from two coherent sources have the displacements represented by
$y_1 = a\cos\omega t$ and $y_2 = a\cos(\omega t + \phi)$
where ϕ is the phase difference between the two displacements. Show that the resultant intensity at a point due to their superposition is given by $I = 4I_0\cos^2\phi/2$, where $I_0 = a^2$.
(b) Hence obtain the conditions for constructive and destructive interference. *(AI 2014C)*

32. In what way is diffraction from each slit related to the interference pattern in a double slit experiment? *(1/3, Delhi 2013)*

33. In a modified set-up of Young's double slit experiment, it is given that $SS_2 - SS_1 = \lambda/4$, *i.e.* the source 'S' is not equidistant from the slits S_1 and S_2.



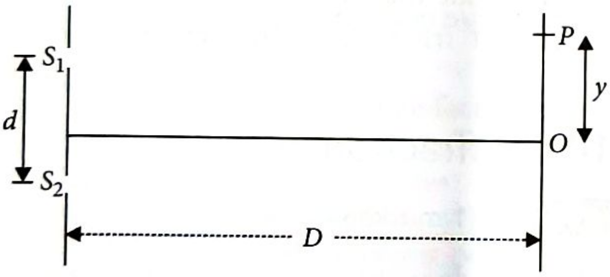
(a) Obtain the conditions for constructive and destructive interference at any point P

on the screen in terms of the path difference $\delta = S_2P - S_1P$.
(b) Does the observed central bright fringe lie above or below 'O'? Give reason to support your answer. *(AI 2013C)*

34. (a) Why are coherent sources necessary to produce a sustained interference pattern?
(b) In Young's double slit experiment using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is K units. Find out the intensity of light at a point where path difference is $\lambda/3$. *(Delhi 2012)*

35. Describe Young's double slit experiment to produce interference pattern due to a monochromatic source of light. Deduce the expression for the fringe width. *(Delhi 2011)*

36. The intensity at the central maxima (O) in Young's double slit experiment is I_0. If the distance OP equals one-third of the fringe width of the pattern, show that the intensity at point P would be $\frac{I_0}{4}$. *(Foreign 2011)*



37. In Young's double slit experiment, the two slits 0.15 mm apart are illuminated by monochromatic light of wavelength 450 nm. The screen is 1.0 m away from the slits.
(a) Find the distance of the second (i) bright fringe, (ii) dark fringe from the central maximum.
(b) How will the fringe pattern change if the screen is moved away from the slits? *(AI 2010)*

38. A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double slit experiment. What is the least distance from the central maximum where the bright fringes due to the both the wavelengths coincide? The distance between the slits is 2 mm and the distance between the plane of the slits and screen is 120 cm. *(Foreign 2010)*

39. A beam of light, consisting of two wavelengths, 600 nm and 450 nm is used to obtained interference fringes in a Young's double slit experiment. Find the least distance, from the central maximum, where the bright fringes, due to both the wavelengths, coincide. The distance between the two slits is 4.0 mm and the screen is at a distance 1.0 m from the slits. *(Delhi 2010C)*

LA (5 marks)

40. Describe any two characteristic features which distinguish between interference and diffraction phenomena. Derive the expression for the intensity at a point of the interference pattern in Young's double slit experiment. *(3/5, Delhi 2019)*

41. In Young's double slit experiment, deduce the condition for (a) constructive, and (b) destructive interference at a point on the screen. Draw a graph showing variation of intensity in the interference pattern against position 'x' on the screen. *(4/5, Delhi 2016)*

42. (a) Consider two coherent sources S_1 and S_2 producing monochromatic waves to produce interference pattern. Let the displacement of the wave produced by S_1 be given by
$Y_1 = a \cos\omega t$
and the displacement by S_2 be
$Y_2 = a \cos(\omega t + \phi)$
Find out the expression for the amplitude of the resultant displacement at a point and show that the intensity at that point will be $I = 4a^2\cos^2\phi/2$.
Hence establish the conditions for constructive and destructive interference.
(b) What is the effect on the interference fringes in Young's double slit experiment when (i) the width of the source slit is increased ; (ii) the monochromatic source is replaced by a source of white light? *(AI 2015)*

43. (a) (i) Two independent monochromatic sources of light cannot produce a sustained interference pattern. Give reason.

(ii) Light waves each of amplitude "a" and frequency "ω", emanating from two coherent light sources superpose at a point. If the displacements due to these waves is given by $y_1 = a \cos \omega t$ and $y_2 = a \cos (\omega t + \phi)$ where ϕ is the phase difference between the two, obtain the expression for the resultant intensity at the point.

(b) In Young's double slit experiment, using monochromatic light of wavelength λ, the intensity of light at a point on the screen where path difference is λ, is K units. Find out the intensity of light at a point where path difference is $\lambda/3$. *(Delhi 2014)*

44. (a) In Young's double slit experiment, describe briefly how bright and dark fringes are obtained on the screen kept in front of a double slit. Hence obtain the expression for the fringe width.

(b) The ratio of the intensities at minima to the maxima in the Young's double slit experiment is 9 : 25. Find the ratio of the widths of the two slits. *(AI 2014)*

45. (a) In Young's double slit experiment, derive the condition for (i) constructive interference and (ii) destructive interference at a point on the screen.

(b) A beam of light consisting of two wavelengths, 800 nm and 600 nm is used to obtain the interference fringes in a Young's double slit experiment on a screen placed 1.4 m away. If the two slits are separated by 0.28 mm, calculate the least distance from the central bright maximum where the bright fringes of the two wavelengths coincide.

(AI 2012)

46. (a) What is the effect on the interference fringes in a Young's double slit experiment when

(i) the separation between the two slits is decreased?

(ii) the width of the source slit is increased?

(iii) the monochromatic source is replaced by a source of white light?

Justify your answer in each case.

(b) The intensity at the central maxima in Young's double slit experimental set-up is I_0. Show that the intensity at a point where the path difference is $\lambda/3$ is $I_0/4$. *(Foreign 2012)*

47. (a) State the importance of coherent sources in the phenomenon of interference.

(b) In Young's double slit experiment to produce interference pattern, obtain the conditions for constructive and destructive interference. Hence deduce the expression for the fringe width.

(c) How does the fringe width get affected, if the entire experimental apparatus of Young's is immersed in water? *(AI 2011)*

48. In Young's double slit experiment, the two slits are kept 2 mm apart and the screen is positioned 140 cm away from the plane of the slits. The slits are illuminated with light of wavelength 600 nm. Find the distance of the third bright fringes, from the central maximum, in the interference pattern obtained on the screen. If the wavelength of the incident light were changed to 480 nm, find out the shift in the position of third bright fringe from the central maximum.

(3/5, AI 2010C)

10.6 Diffraction

VSA (1 mark)

49. How does the angular separation between fringes in single-slit diffraction experiment change when the distance of separation between the slit and screen is doubled?

(AI 2012)

50. For a given single slit, the diffraction pattern is obtained on a fixed screen, first by using red light and then with blue light. In which case, will the central maxima, in the observed diffraction pattern, have a larger angular width? *(Delhi 2010C)*

SA I (2 marks)

51. Explain giving reason, how the resolving power of a compound microscope depends on the

(a) frequency of the incident light

(b) focal length of the objective lens?

(AI 2019)

52. When are two objects just resolved? Explain. How can the resolving power of a compound microscope be increased? Use relevant formula to support your answer.

(Delhi 2017)

53. Draw the intensity pattern for single slit diffraction and double slit interference. Hence, state two differences between interference and diffraction patterns.

(AI 2017)

54. A parallel beam of light of 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that the first minimum is at a distance of 2.5 mm from the centre of the screen. Calculate the width of the slit. *(AI 2013)*

55. Yellow light (λ = 6000 Å) illuminates a single slit of width 1×10^{-4} m. Calculate (i) the distance between the two dark lines on either side of the central maximum, when the diffraction pattern is viewed on a screen kept 1.5 m away from the slit; (ii) the angular spread of the first diffraction minimum.

(AI 2012C)

56. Two convex lenses of same focal length but of aperture A_1 and A_2 ($A_2 < A_1$), are used as the objective lenses in two astronomical telescope having identical eyepieces. What is the ratio of their resolving power? Which telescope will you prefer and why? Give reason. *(Delhi 2011)*

57. Yellow light (λ = 6000 Å) illuminates a single slit of width 1×10^{-4} m. Calculate the distance between two dark lines on either side of the central maximum, when the diffraction pattern is viewed on a screen kept 1.5 m away from the slit. *(AI 2011C)*

SA II (3 marks)

58. Define resolving power of a microscope and write one factor on which it depends.

(1/3, AI 2017)

59. A parallel beam of monochromatic light falls normally on a narrow slit of width 'a' to produce a diffraction pattern on the screen placed parallel to the plane of the slit.
Use Huygens' principle to explain that
(i) the central bright maxima is twice as wide as the other maxima.
(ii) the intensity falls as we move to successive maxima away from the centre of on either side. *(Delhi 2014C)*

60. Two wavelengths of sodium light 590 nm and 596 nm are used, in turn to study the diffraction taking place at a single slit of aperture 2×10^{-4} m. The distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of the first maxima of the diffraction pattern obtained in the two cases. *(2/3, Delhi 2013)*

61. Use Huygen's principle to explain the formation of diffraction pattern due to a single slit illuminated by a monochromatic source of light.
When the width of the slit is made double the original width, how would this affect the size and intensity of the central diffraction band?

(Delhi 2012)

62. In a single slit diffraction experiment, the width of the slit is reduced to half its original width. How would this affect the size and intensity of the central maximum?

(2/3, Delhi 2012C)

63. Define the resolving power of a microscope. Write two factors by which resolving power can be increased. *(2/3, AI 2012C)*

64. What would be the effect on the resolving power of the telescope if its objective lens is immersed in a transparent medium of higher refractive index? *(1/3, AI 2012C)*

65. (a) In a single slit diffraction pattern, how does the angular width of the central maximum vary, when
(i) aperture of slit is increased?
(ii) distance between the slit and the screen is decreased?
(b) How is the diffraction pattern different from the interference pattern obtained in Young's double slit experiment?

(Delhi 2011C)

66. Define the resolving power of a microscope. How is this affected when

(i) the wavelength of illuminating radiations is decreased, and

(ii) the diameter of the objective lens is decreased?

Justify your answer. *(Foreign 2010)*

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

(a) the width of the slit.

(b) the distance of the second maximum from the centre of the screen.

(c) the width of the central maximum.

(Foreign 2010)

LA (5 marks)

68. In the diffraction due to a single slit experiment, the aperture of the slit is 3 mm. If monochromatic light of wavelength 620 nm is incident normally on the slit, calculate the separation between first order minima and the 3rd order maxima on one side of the screen. The distance between the slit and the screen is 1.5 m. (2/5, *Delhi 2019*)

69. (a) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band? Explain.

(b) When a tiny circular obstacle is placed in the path of light from a distant source, a bright spot in seen at the centre of the obstacle. Explain why. *(3/5, 2018)*

70. (a) Explain two features to distinguish between the interference pattern in Young's double slit experiment with the diffraction pattern obtained due to a single slit.

(b) A monochromatic light of wavelength 500 nm is incident normally on a single slit of width 0.2 mm to produce a diffraction pattern. Find the angular width of the central maximum obtained on the screen.

Estimate the number of fringes obtained in Young's double slit experiment with fringe width 0.5 mm, which can be accommodated within the region of total angular speed of the central maximum due to single slit.

(Delhi 2017)

71. Compare the interference pattern observed in Young's double slit experiment with single slit diffraction pattern, pointing out three distinguishing features. *(1/5, Delhi 2016)*

72. (i) State the essential conditions for diffraction of light.

(ii) Explain diffraction of light due to a narrow single slit and the formation of pattern of fringes on the screen.

(iii) Find the relation for width of central maximum in terms of wavelength 'λ' width of slit 'a' and separation between slit and screen 'D'.

(iv) If the width of the slit is made double the original width, how does it affect the size and intensity of the central band?

(Foreign 2016)

73. (a) Using Huygens' construction of secondary wavelets explain how a diffraction pattern is obtained on a screen due to a narrow slit on which a monochromatic beam of light is incident normally.

(b) Show that the angular width of the first diffraction fringe is half that of the central fringe.

(c) Explain why the maxima at $\theta = \left(n+\frac{1}{2}\right)\frac{\lambda}{a}$ become weaker and weaker with increasing n. *(Delhi 2015)*

74. (a) Describe briefly how a diffraction pattern is obtained on a screen due to a single narrow slit illuminated by a monochromatic source of light. Hence obtain the conditions for the angular width of secondary maxima and secondary minima.

(b) Two wavelengths of sodium light of 590 nm and 596 nm are used in turn to study the diffraction taking place at a single slit of aperture 2×10^{-6} m. The distance between the slit and the screen is 1.5 m. Calculate the separation between the positions of first maxima of the diffraction pattern obtained in the two cases. *(AI 2014)*

75. (a) Write three characteristic features to distinguish between the interference fringes in Young's double slit experiment and the diffraction pattern obtained due to a narrow single slit.
(b) A parallel beam of light of wavelength 500 nm falls on a narrow slit and the resulting diffraction pattern is observed on a screen 1 m away. It is observed that the first minimum is a distance of 2.5 mm away from the centre. Find the width of the slit. *(Foreign 2014)*

76. (a) A monochromatic source of light of wavelength λ illuminates a narrow slit of width d to produce a diffraction pattern on the screen. Obtain the conditions when secondary wavelets originating from the slit interfere to produce maxima and minima on the screen.
(b) How would the diffraction pattern be affected when
(i) the width of the slit is decreased?
(ii) the monochromatic source of light is replaced by white light? *(Foreign 2013)*

77. (a) Obtain the conditions for the bright and dark fringes in diffraction pattern due to a single narrow slit illuminated by a monochromatic source.
Explain clearly why the secondary maxima go on becoming weaker with increasing n.
(b) When the width of the slit is made double, how would this affect the size and intensity of the central diffraction band ? Justify. *(Foreign 2012)*

78. (a) In a single narrow slit (illuminated by a monochromatic source) diffraction experiment, deduce the conditions for the central maximum and secondary maxima and minima observed in the diffraction pattern. Also explain why the secondary maxima go on becoming weaker in intensity as the order increases.
(b) Answer the following questions:
(i) How does the width of the slit affect the size of the central diffraction band?
(ii) When a tiny circular obstacle is placed in the path of light from a distant source, why is a bright spot seen at the centre of the shadow of the obstacle? *(AI 2010C)*

10.7 Polarisation

VSA (1 mark)

79. Distinguish between unpolarized and linearly polarized light. *(Delhi 2019)*

80. Which of the following waves can be polarized (i) Heat waves (ii) Sound waves? Give reason to support your answer. *(Delhi 2013)*

81. In what way is plane polarised light different from an unpolarised light? *(AI 2012C)*

SA I (2 marks)

82. Unpolarised light is passed through a polaroid P_1. When this polarised beam passes through another polaroid P_2 and if the pass axis of P_2 makes angle θ with the pass axis of P_1, then write the expression for the polarised beam passing through P_2. Draw a plot showing the variation of intensity when θ varies from 0 to 2π. *(AI 2017)*

83. State Brewster's law.
The value of Brewster angle for a transparent medium is different for light of different colours. Give reason. *(Delhi 2016)*

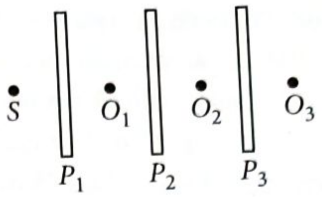
84. Distinguish between polarized and unpolarized light. Does the intensity of polarized light emitted by a polaroid depend on its orientation? Explain briefly.
The vibration in beam of polarized light make an angle of 60° with the axis of the polaroid sheet. What percentage of light is transmitted through the sheet? *(Foreign 2016)*

85. Find an expression for intensity of transmitted light when a polaroid sheet is rotated between two crossed polaroids. In which position of the polaroid sheet will the transmitted intensity be maximum? *(Delhi 2015)*

rotated? Explain by drawing the necessary diagram. *(Delhi 2014C)*

108. (a) Describe briefly how an unpolarised light get linearly polarized when it passes through a polaroid.

(b) Three identical polaroid sheets P_1, P_2 and P_3 are oriented so that the pass axis of P_2 and P_3 are inclined at angle of 60° and 90° respectively with respect to the pass axis of P_1. A monochromatic source S of unpolarised light of intensity I_0 is kept in front of the polaroid sheet P_1 as shown in the figure. Determine the intensities of light as observed by the observers O_1, O_2 and O_3 as shown. *(Delhi 2013C)*



109. (a) How does an unpolarized light incident on a polaroid get polarized?

Describe briefly, with the help of a necessary diagram, the polarization of light by reflection from a transparent medium.

(b) Two polaroids 'A' and 'B' are kept in crossed position. How should a third polaroid 'C' be placed between them so that the intensity of polarized light transmitted by polaroid B reduces to $1/8^{th}$ of the intensity of unpolarized light incident on A? *(AI 2012)*

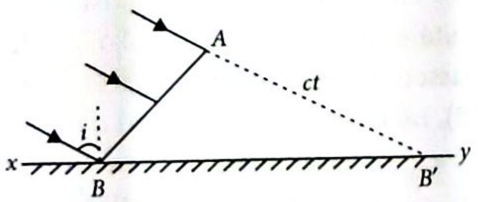
Detailed Solutions

1. According to Huygens' principle, each point on a wavefront is a source of secondary waves, which add up to give a wavefront at any later time.

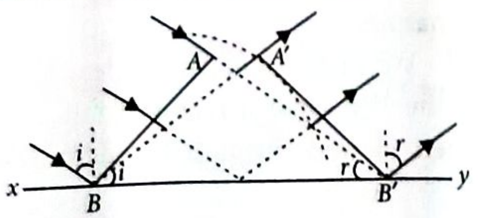
2. A source of light sends the disturbance in all the directions and continuous locus of all the particles vibrating in same phase at any instant is called as wavefront.

Laws of reflection by Huygens' principle :

Let us consider a plane wavefront AB incident on the plane reflecting surface xy. Incident rays are normal to the wavefront AB.



Let in time t the secondary wavelets reaches B' covering a distance ct. Similarly from each point on primary wavefront AB. Secondary wavelets start growing with the speed c. To find reflected wavefront after time t, let us draw a sphere of radius ct taking B as center and now a tangent is drawn from B' on the sphere the tangent $B'A'$ represents reflected wavefront after time t.



For every point on wavefront AB a corresponding point lie on the reflected wavefront $A'B'$.

So, comparing two triangle $\Delta BAB'$ and $\Delta B'A'B$

We find that

$AB' = A'B = ct$

BB' = common

$\angle A = \angle A' = 90°$

Thus two triangles are congruent, hence $\angle i = \angle r$

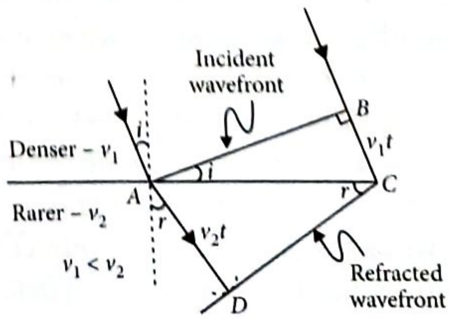
This proves first law of reflection.

Also incident rays, reflected rays and normal to them all lie in the same plane. This gives second law of reflection.

3. Refractive index (μ) : Refractive index of a medium is defined as the ratio of the speed of light in vacuum to the speed of light in that medium. *i.e.*,

$$\mu = \frac{c}{v} = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}}$$

Given figure shows the refraction of a plane wavefront at a rarer medium *i.e.*, $v_2 > v_1$



Let the angles of incidence and refraction be i and r respectively.
From right ΔABC, we have,

$$\sin \angle BAC = \sin i = \frac{BC}{AC}$$

From right ΔADC, we have,

$$\sin \angle DCA = \sin r = \frac{AD}{AC}$$

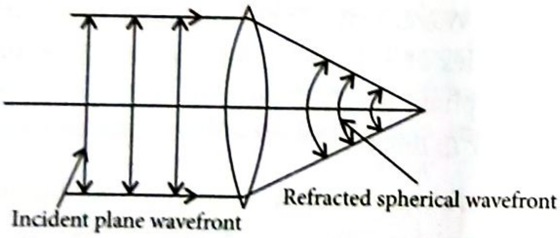
$$\therefore \quad \frac{\sin i}{\sin r} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t}$$

or $\frac{\sin i}{\sin r} = \frac{v_1}{v_2} = {}^1\mu_2$ (a constant)

This verifies Snell's law of refraction. The constant ${}^1\mu_2$ is called the refractive index of the second medium with respect to first medium.

4. Wavefront : The continuous locus of all the particles of a medium, which are vibrating in the same phase is called a wavefront.

Refer to answer 1.



5. (i) Reflection and refraction arise through interaction of incident light with atomic constituents of matter which vibrate with the same frequency as that of the incident light. Hence frequency remains unchanged.

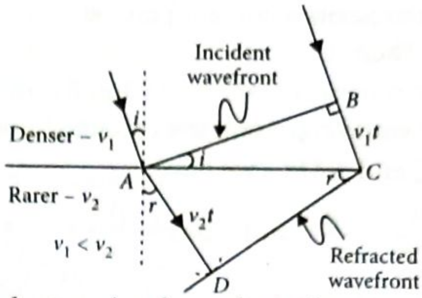
(ii) Energy carried by a wave depends on the frequency of the wave, not on the speed of wave propagation.

(iii) For a given frequency, intensity of light in the photon picture is determined by

$$I = \frac{\text{Energy of photons}}{\text{area} \times \text{time}} = \frac{n \times h\upsilon}{A \times t}$$

Where n is the number of photons incident normally on crossing area A in time t.

6. Given figure shows the refraction of a plane wavefront at a rarer medium *i.e.*, $v_2 > v_1$



The incident and refracted wavfronts are shown in figure.
Let the angles of incidence and refraction be i and r respectively.
From right ΔABC, we have,

$$\sin \angle BAC = \sin i = \frac{BC}{AC}$$

From right ΔADC, we have,

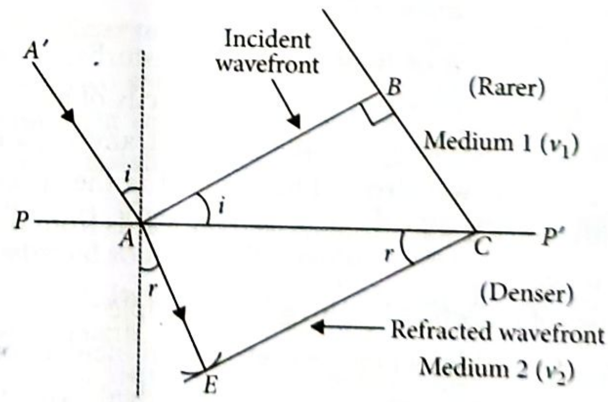
$$\sin \angle DCA = \sin r = \frac{AD}{AC}$$

$$\therefore \quad \frac{\sin i}{\sin r} = \frac{BC}{AD} = \frac{v_1 t}{v_2 t} \text{ or } \frac{\sin i}{\sin r} = \frac{v_1}{v_2} = {}^1\mu_2$$

(a constant)

This verifies Snell's law of refraction. The constant ${}^1\mu_2$ is called the refractive index of the second medium with respect to first medium. .

7. Snell's law of refraction : Let PP' represents the surface separating medium 1 and medium 2 as shown in figure.



Let v_1 and v_2 represents the speed of light in medium 1 and medium 2 respectively. We assume a plane wavefront AB propagating in the direction $A'A$ incident on the interface at an angle i. Let t be the time taken by the wavefront to travel the distance BC.

$\therefore \quad BC = v_1 t$ [$\because$ distance = speed × time]

In order to determine the shape of the refracted wavefront, we draw a sphere of radius $v_2 t$ from the point A in the second medium (the speed of the wave in second medium is v_2).

Let CE represents a tangent plane drawn from the point C. Then

$AE = v_2 t$

$\therefore$ CE would represent the refracted wavefront.

In ΔABC and ΔAEC, we have

$$\sin i = \frac{BC}{AC} = \frac{v_1 t}{AC} \text{ and } \sin r = \frac{AE}{AC} = \frac{v_2 t}{AC}$$

Where i and r are the angles of incident and refraction respectively.

$$\therefore \quad \frac{\sin i}{\sin r} = \frac{v_1 t}{AC} \cdot \frac{AC}{v_2 t}$$

$$\frac{\sin i}{\sin r} = \frac{v_1}{v_2}$$

If c represents the speed of light in vacuum, then

$$\mu_1 = \frac{c}{v_1} \text{ and } \mu_2 = \frac{c}{v_2}$$

$$\Rightarrow \quad v_1 = \frac{c}{\mu_1} \text{ and } v_2 = \frac{c}{\mu_2}$$

Where μ_1 and μ_2 are the refractive indices of medium 1 and medium 2.

$$\therefore \quad \frac{\sin i}{\sin r} = \frac{c/\mu_1}{c/\mu_2} \Rightarrow \frac{\sin i}{\sin r} = \frac{\mu_2}{\mu_1} \Rightarrow \mu_1 \sin i = \mu_2 \sin r$$

This is the Snell's law of refraction.

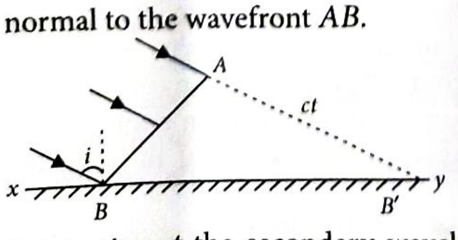
8. *Refer to answer 6.*

9. *Refer to answer 7.*

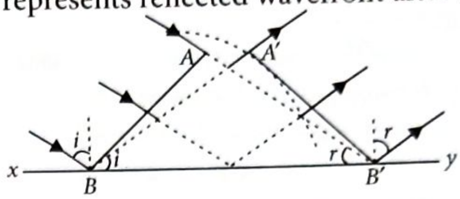
10. A source of light sends the disturbance in all the directions and continuous locus of all the particles vibrating in same phase at any instant is called as wavefront. Phase speed is the speed with which a wavefront moved outwards from the source.

Laws of reflection by Huygens' principle :

Let us consider a plane wavefront AB incident on the plane reflecting surface xy. Incident rays are normal to the wavefront AB.



Let in time t the secondary wavelets reaches B' covering a distance ct. Similarly from each point on primary wavefront AB. Secondary wavelets start growing with the speed c. To find reflected wavefront after time t, let us draw a sphere of radius ct taking B as center and now a tangent is drawn from B' on the sphere the tangent $B'A'$ represents reflected wavefront after time t.



For every point on wavefront AB a corresponding point lie on the reflected wavefront $A'B'$.

So, comparing two triangle $\Delta BAB'$ and $\Delta B'A'B$

We find that

$$AB' = A'B = ct$$

$$BB' = \text{common}$$

$$\angle A = \angle A' = 90^\circ$$

Thus two triangles are congruent, hence $\angle i = \angle r$

This proves first law of reflection.

Also incident rays, reflected rays and normal to them all lie in the same plane. This gives second law of reflection.

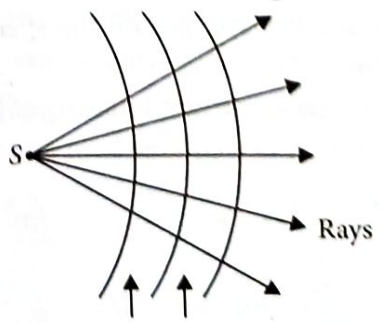
11. (i) Wavefront : The continuous locus of all the particles of a medium, which are vibrating in the same phase is called a wavefront.

(ii) *Refer to answer 7.*

12. (a) A wavefront is defined as the locus of all the particles vibrating in same phase at any instant.

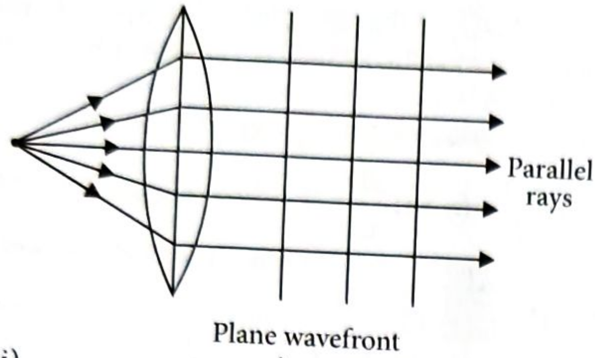
A line perpendicular to the wavefront in the direction of propagation of light wave is called a ray.

(b) (i) The wavefront will be spherical of increasing radius as shown in figure.

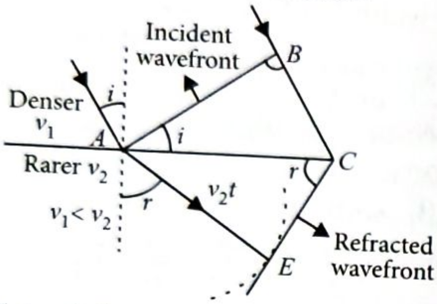


Spherical wavefront

(ii) When source is at the focus, the rays coming out of the convex lens are parallel, so wavefront is plane as shown in figure.



(iii)

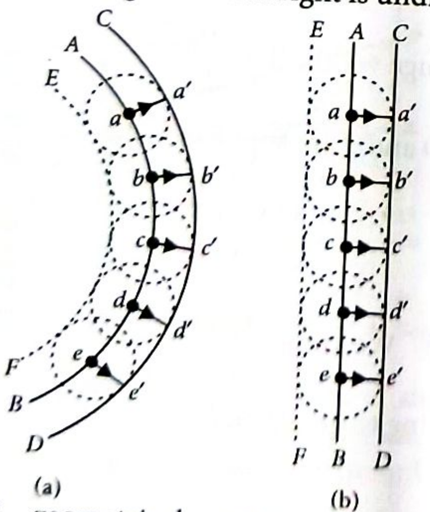


13. (a) *Refer to answer 1*
Refer to answer 7.

(b) (i) *Refer to answer 5(i).*

(ii) Since the frequency remains same, hence there is no reduction in energy.

14. (a) Consider a spherical or plane wavefront moving towards right. Let AB be its position at any instant of time. The region on its left has received the wave while region on the right is undisturbed.



Huygens' geometrical construction for the propagation of (a) spherical, (b) plane wavefront. According to Huygens' principle, each point on AB becomes a source of secondary disturbance, which takes with the same speed c. To find the new wavefront after time t, we draw spheres of radii ct, from each point on AB.

The forward envelope or the tangential surface CD of the secondary wavelets gives the new wavefront after time t.

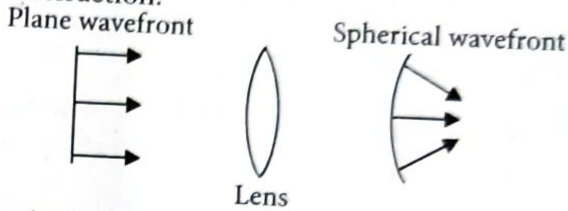
The lines aa', bb', cc', etc., are perpendicular to both AB and CD. Along these lines, the energy flows from AB to CD. So these lines represent the rays. Rays are always normal to wavefronts.

(b) *Refer to answer 6.*

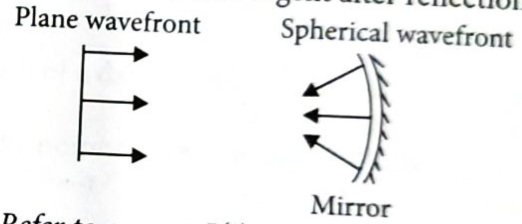
(c) *Refer to answer 5 (i).*

15. *Refer to answer 7.*

16. (a) (i) The action of convex lens : A plane wavefront becomes spherical convergent wavefront after refraction.



(ii) Action of concave mirror : A plane wavefront becomes spherical convergent after reflection.



(b) *Refer to answer 5(i).*

17. (i) and (ii) *Refer to answer 6.*

(iii) No, because energy of wave depends on its frequency and not on its speed.

18. *Refer to answer 10.*

19. Two sources are said to be coherent, if they emit light waves of same frequency or wavelength and of a stable phase difference.

20. (a) The essential condition, which must satisfied sources to be coherent are :

(i) the two light waves should be of same wavelength.

(ii) the two light waves should either be in phase or should have a constant phase difference.

(b) Because coherent sources emit light waves of same frequency or wavelength and of a stable phase difference.

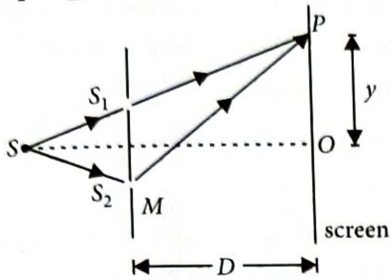
21. (a) Given : $SS_2 - SS_1 = \dfrac{\lambda}{4}$

Now path difference between the two waves from slit S_1 and S_2 on reaching point P on screen is

$\Delta x = (SS_2 + S_2P) - (SS_1 + S_1P)$

or $\Delta x = (SS_2 - SS_1) + (S_2P - S_1P)$

or $\Delta x = \frac{\lambda}{4} + \frac{yd}{D}$, where d is the slits separation.



For constructive interference at point P, path difference, $\Delta x = n\lambda$ or $\frac{\lambda}{4} + \frac{yd}{D} = n\lambda$

or $\frac{yd}{D} = \left(n - \frac{1}{4}\right)\lambda$ ...(i)

where $n = 0, 1, 2, 3, \ldots,$

(b) From equation (i), $y_n = \left(n - \frac{1}{4}\right)\frac{\lambda D}{d}$

and $y_{n-1} = \left(n - 1 - \frac{1}{4}\right)\frac{\lambda D}{d}$

The fringe width is given by separation of two consecutive bright fringes.

$$\beta = y_n - y_{n-1} = \left(n - \frac{1}{4}\right)\frac{\lambda D}{d} - \left(n - 1 - \frac{1}{4}\right)\frac{\lambda D}{d}$$

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

22. For a single slit of width "a" the first minima of the interference pattern of a monochromatic light of wavelength λ occurs at an angle of (λ/a) because the light from centre of the slit differs by a half of a wavelength.
Whereas a double slit experiment at the same angle of (λ/a) and slits separation "a" produces maxima because one wavelength difference in path length from these two slits is produced.

23. (a) *Refer to answer 20(a).*
(b) For bright fringes (maxima),

Path difference, $\frac{xd}{D} = n\lambda$

$\therefore \quad x = n\lambda\frac{D}{d}$, where $n = 0, 1, 2, 3, \ldots$

For dark fringes (minima),

path difference, $\frac{xd}{D} = (2n-1)\frac{\lambda}{2}$

$\therefore \quad x = (2n-1)\frac{\lambda}{2}\frac{D}{d}$, where $n = 1, 2, 3, \ldots$

The separation between the centre of two consecutive bright fringes is the width of a dark fringe.

$\therefore$ Fringe width, $\beta = x_n - x_{n-1}$

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

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

24. Fringe width $\beta = \frac{D\lambda}{d}$; $\beta \propto \lambda$

$\therefore \quad \frac{\beta_1}{\beta_2} = \frac{\lambda_1}{\lambda_2}$ or $\lambda_2 = \frac{\beta_2}{\beta_1}\lambda_1 = \frac{8.1}{7.2} \times 640$ nm

$\lambda_2 = 720$ nm

$\because \quad x = n_1\beta_1 = n_2\beta_2$

or $\frac{n_1 D\lambda_1}{d} = \frac{n_2\lambda_2 D}{d}$ or $n_1\lambda_1 = n_2\lambda_2$

$\because$ Bright fringes coincides at least distance x, if $n_1 = n_2 + 1 \Rightarrow n_1 \times 640 = (n_1 - 1) \times 720$

$\frac{n_1 - 1}{n_1} = \frac{640}{720}$ or $n_1 = 9$

25. Here, $d = 1$ mm $= 1 \times 10^{-3}$ m
$D = 1$ m, $\lambda = 500$ nm $= 5 \times 10^{-7}$ m
Fringe spacing,

$$\beta = \frac{\lambda D}{d} = \frac{5 \times 10^{-7} \times 1}{1 \times 10^{-3}} = 5 \times 10^{-4} \text{ m} = 0.5 \text{ mm}$$

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

When D and d are kept fixed, $\frac{\beta}{\beta_1} = \frac{\lambda}{\lambda_1}$

or $\lambda_1 = \frac{\lambda\beta_1}{\beta} = \frac{630 \times 8.1}{7.2} = \frac{5103}{7.2} = 708.75$ nm

27. (a) We know, $\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$

According to question, $I_2 = 50\%$ of I_1

$I_2 = 0.5I_1$; $a_2^2 = 0.5\, a_1^2$ $\quad (\because I \propto a^2)$

$a_2 = \frac{a_1}{\sqrt{2}}$

Hence,

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_1/\sqrt{2})^2}{(a_1 - a_1/\sqrt{2})^2} = \frac{(1 + 1/\sqrt{2})^2}{(1 - 1/\sqrt{2})^2}$$

$$= \left(\frac{\sqrt{2}+1}{\sqrt{2}-1}\right)^2 \approx 34$$

(b) The central fringes are white. On the either side of the central white fringe the coloured bands (few coloured maxima and minima) will appear. This is because fringes of different colours overlap.

28. (a) Angular width, $\theta = \frac{\lambda}{d}$ or $d = \frac{\lambda}{\theta}$

Here, $\lambda = 600$ nm $= 6 \times 10^{-7}$ m

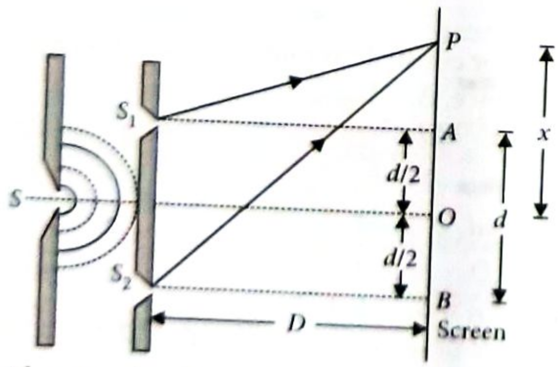
$\theta = 0.1° = \frac{0.1 \times \pi}{180}$ rad $= \frac{\pi}{1800}$ rad, $d = ?$

$\therefore \quad d = \frac{6 \times 10^{-7} \times 1800}{\pi} = 3.44 \times 10^{-4}$ m

(b) Frequency of a light depends on its source only. So, the frequencies of reflected and refracted light will be same as that of incident light.
Reflected light is in the same medium (air) so its wavelength remains same as 500 Å.

Wavelength of refracted light, $\lambda_r = \frac{\lambda}{\mu_w}$
μ_w = refractive index of water.
So, wavelength of refracted wave will be decreased.

29. (i) Two independent monochromatic sources cannot produce sustained interference pattern because the phase difference between the light waves from two independent sources keeps on changing continuously.
(ii)



Consider a point P on the screen at distance x from the centre O. The nature of the interference at the point P depends on path difference,
$p = S_2P - S_1P$
From right-angled ΔS_2BP and ΔS_1AP,
$(S_2P)^2 - (S_1P)^2 = [S_2B^2 + PB^2] - [S_1A^2 + PA^2]$

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

or $(S_2P - S_1P)(S_2P + S_1P) = 2xd$

or $\quad S_2P - S_1P = \frac{2xd}{S_2P + S_1P}$

In practice, the point P lies very close to O, therefore $S_1P \approx S_2P \approx D$. Hence

$p = S_2P - S_1P = \frac{2xd}{2D}$

or $\quad p = \frac{xd}{D}$

Positions of bright fringes : For constructive interference,

$p = \frac{xd}{D} = n\lambda$

or $\quad x = \frac{nD\lambda}{d}$ where $n = 0, 1, 2, 3, ...$

Positions of dark fringes : For destructive interference,

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

or $\quad x = (2n-1)\frac{D\lambda}{2d}$ where $n = 1, 2, 3$

Width of a dark fringe = Separation between two consecutive bright fringes

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

Width of bright fringe = Separation between two consecutive dark fringes

$= x'_n - x'_{n-1} = (2n-1)\frac{D\lambda}{2d} - [2(n-1)-1]\frac{D\lambda}{2d} = \frac{D\lambda}{d}$

Clearly, both the bright and dark fringes are of equal width.
Hence the expression for the fringe width in Young's double slit experiment can be written as

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

30. (a) The intensity of light due to slit is directly proportional to width of slit.

$\therefore \quad \frac{I_1}{I_2} = \frac{w_1}{w_2} = \frac{4}{1}$

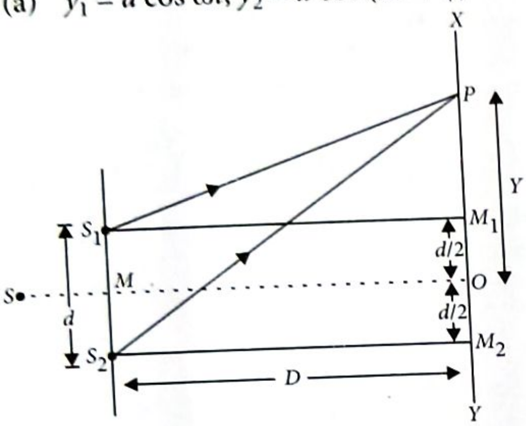
$\Rightarrow \quad \frac{a_1^2}{a_2^2} = \frac{4}{1}$ or $\frac{a_1}{a_2} = \frac{2}{1}$ or $a_1 = 2a_2$

$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(2a_2 + a_2)^2}{(2a_2 - a_2)^2} = \frac{9a_2^2}{a_2^2} = 9:1$

(b) No, the appearance of bright and dark fringes in the interference pattern does not violate the law of conservation of energy.

When interference takes place, the light energy which disappears at the regions of destructive interference appears at regions of constructive interference so that the average intensity of light remains the same. Hence, the law of conservation of energy is obeyed in the phenomenon of interference of light.

31. (a) $y_1 = a\cos\omega t$, $y_2 = a\cos(\omega t + \phi)$



where ϕ is phase difference between them. Resultant displacement at point P will be,

$y = y_1 + y_2 = a\cos\omega t + a\cos(\omega t + \phi)$

$= a[\cos\omega t + \cos(\omega t + \phi)]$

$$= a\left[2\cos\frac{(\omega t + \omega t + \phi)}{2}\cos\frac{(\omega t - \omega t - \phi)}{2}\right]$$

$$y = 2a\cos\left(\omega t + \frac{\phi}{2}\right)\cos\left(\frac{\phi}{2}\right) \quad ...(i)$$

Let $y = 2a\cos\left(\frac{\phi}{2}\right) = A$, the equation (i) becomes

$$y = A\cos\left(\omega t + \frac{\phi}{2}\right)$$

where A is amplitude of resultant wave,

Now, $A = 2a\cos\left(\frac{\phi}{2}\right)$

On squaring, $A^2 = 4a^2\cos^2\left(\frac{\phi}{2}\right)$

Hence, resultant intensity,

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

(b) Condition for constructive interference, $\cos\Delta\phi = +1$

$2\pi\frac{\Delta x}{\lambda} = 0, 2\pi, 4\pi...$

or $\Delta x = n\lambda$; $n = 0, 1, 2, 3, ...$

Condition for destructive interference, $\cos\Delta\phi = -1$

$2\pi\frac{\Delta x}{\lambda} = \pi, 3\pi, 5\pi...$

or $\Delta x = (2n - 1)\lambda/2$

where $n = 1, 2, 3...$

32. If the width of each slit is comparable to the wavelength of light used, the interference pattern thus obtained in the double-slit experiment is modified by diffraction from each of the two slits.

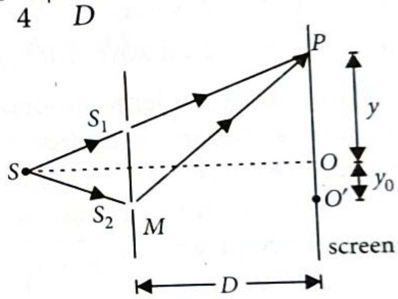
33. (a) Given : $SS_2 - SS_1 = \frac{\lambda}{4}$

Now path difference between the two waves from slit S_1 and S_2 on reaching point P on screen is

$\Delta x = (SS_2 + S_2P) - (SS_1 + S_1P)$

or $\Delta x = (SS_2 - SS_1) + (S_2P - S_1P)$

or $\Delta x = \frac{\lambda}{4} + \frac{yd}{D}$



(i) For constructive interference at point P, path difference, $\Delta x = n\lambda$

or $\frac{\lambda}{4} + \frac{yd}{D} = n\lambda$

or $\frac{yd}{D} = \left(n - \frac{1}{4}\right)\lambda \quad ...(i)$

where $n = 0, 1, 2, 3,...,$

(ii) For destructive interference at point P, path difference

$\Delta x = (2n-1)\frac{\lambda}{2}$ or $\frac{\lambda}{4} + \frac{yd}{D} = (2n-1)\frac{\lambda}{2}$

or $\frac{yd}{D} = \left(2n - 1 - \frac{1}{2}\right)\frac{\lambda}{2} = (4n-3)\frac{\lambda}{4} \quad ...(ii)$

where $n = 1, 2, 3, 4,...$

For central bright fringe, putting $n = 0$ in equation (i), we get

$\frac{yd}{D} = -\frac{\lambda}{4}$ or $y = \frac{-\lambda D}{4d}$

(b) The negative sign indicates that central bright fringe will be observed at a point O' below the centre O of screen.

34. (a) Coherent sources are necessary to produce a sustained interference pattern otherwise the phase difference changes very rapidly with time and hence no interference will be observed.

(b) Intensity at a point, $I = 4I_0 \cos^2\left(\frac{\phi}{2}\right)$

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

At path difference λ,

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

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

[$\because$ Given $I = K$, at path difference λ]

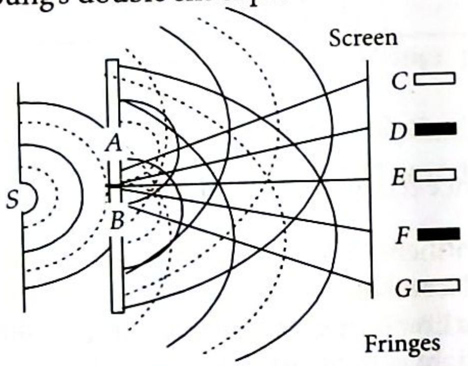
$K = 4I_0$ ...(i)

If path difference is $\frac{\lambda}{3}$, then phase difference will be

$$\phi' = \frac{2\pi}{\lambda} \times \frac{\lambda}{3} = \frac{2\pi}{3}$$

$\therefore$ Intensity, $I' = 4I_0 \cos^2\left(\frac{2\pi}{6}\right) = \frac{K}{4}$ (Using (i))

35. Young's double slit experiment :



S is a narrow slit (of width about 1 mm) illuminated by a monochromatic source of light, S. At a suitable distance (about 10 cm) from S, there are two fine slits A and B about 0.5 mm apart placed symmetrically parallel to S. When a screen is placed at a large distance (about 2 m) from the slits A and B, alternate bright and dark fringes running parallel to the lengths of slits appear on the screen. These are the interference fringes. The fringes disappear when one of the slits A or B is covered.

Expression for fringe width β:

Refer to answer 29(ii).

36. Fringe width $(\beta) = \frac{\lambda D}{d}$

$$y = \frac{\beta}{3} = \frac{\lambda D}{3d}$$

Path difference $(\Delta p) = \frac{yd}{D} \Rightarrow \Delta p = \frac{\lambda D}{3d} \cdot \frac{d}{D} = \frac{\lambda}{3}$

$$\Delta\phi = \frac{2\pi}{\lambda} \cdot \Delta p = \frac{2\pi}{\lambda} \cdot \frac{\lambda}{3} = \frac{2\pi}{3}$$

Intensity at point $P = I_0 \cos^2 \Delta\phi$

$$= I_0\left[\cos\frac{2\pi}{3}\right]^2 = I_0\left(\frac{1}{2}\right)^2 = \frac{I_0}{4}$$

37. Given that distance between the two slits, $d = 0.15$ mm

Wavelength of monochromatic light, $\lambda = 450$ nm

Distance between the screen and slits, $D = 1$ m

(a) (i) Distance of n^{th} bright fringe from central maximum $= \frac{n\lambda D}{d}$

$$= 2 \times \frac{450 \times 10^{-9} \times 1}{0.15 \times 10^{-3}} \quad [\because n = 2]$$

$= 6 \times 10^{-3}$ m $= 6$ mm

(ii) Distance of n^{th} dark fringe from central maximum

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

$$= (2 \times 2 - 1) \times \frac{450 \times 10^{-9} \times 1}{2 \times 0.15 \times 10^{-3}} \quad [\because n = 2]$$

$$= \frac{3}{2} \times 3 \times 10^{-3} = 4.5 \text{ mm}$$

(b) Since, width of bright or dark fringes is given by $\beta = \frac{\lambda D}{d}$,

Thus when screen is moved away, D increases and hence fringe width increases.

38. For least distance of coincidence of fringes, there must be a difference of 1 in order of λ_1 and λ_2.

As $\lambda_1 > \lambda_2$, $n_1 < n_2$

If $n_1 = n$, $n_2 = n + 1$

$\therefore$ $(y_n)_{\lambda_1} = (y_{n+1})_{\lambda_2} \Rightarrow \frac{nD\lambda_1}{d} = \frac{(n+1)D\lambda_2}{d}$

$\Rightarrow$ $n\lambda_1 = (n+1)\lambda_2$

$\Rightarrow$ $n = \frac{\lambda_2}{\lambda_1 - \lambda_2} = \frac{520 \text{ nm}}{(650 - 520) \text{ nm}}$ or $n = \frac{520}{130} = 4$

$= 2.6 \times 10^{-3}$ m $= 2.6$ mm

Here $D = 120$ cm $= 1.20$ m
and $d = 2$ mm $= 2 \times 10^{-3}$ m
$\therefore$ Least distance,

$$y_{min} = \frac{nD\lambda_1}{d} = \frac{4 \times 1.2 \times 650 \times 10^{-9}}{2 \times 10^{-3}} \text{ m}$$
$= 1.56 \times 10^{-3}$ m $= 1.56$ mm

39. Here $d = 4.0$ mm $= 4 \times 10^{-3}$ m, $D = 1.0$ m
For wavelength $\lambda_A = 600$ nm $= 600 \times 10^{-9}$ m $= 6 \times 10^{-7}$ m
For wavelength $\lambda_B = 450$ nm $= 450 \times 10^{-9}$ m $= 4.5 \times 10^{-7}$ m
As $\lambda_A = \lambda_B$, $n_A = n_B$
If $n_A = n$ then $n_B = n + 1$
$\therefore \quad (y_n)\lambda_A = (y_{n+1})\lambda_B$
$\Rightarrow \quad n\lambda_A = (n+1)\lambda_B$

or, $\quad n = \dfrac{\lambda_B}{\lambda_A - \lambda_B} = \dfrac{450}{150} = 3$

$\therefore$ Least distance from central maxima,

$$\lambda_{min} = \frac{3 \times 1 \times 600 \times 10^{-9}}{4 \times 10^{-3}} = 0.45 \times 10^{-3} \text{ m} = 0.45 \text{ mm}$$

40. Difference between interference and diffraction :

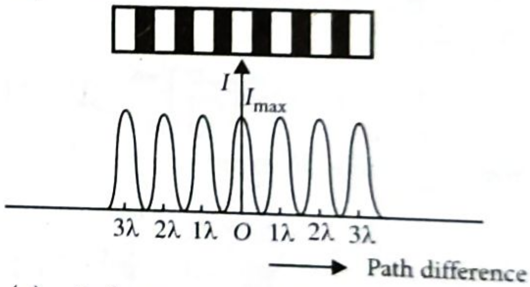
Interference	Diffraction
1. Interference is caused by superposition of two waves starting from two coherent sources.	1. Diffraction is caused by superposition of a number of waves starting from the slit.
2. All bright and dark fringes are of equal width.	2. Width of central bright fringe is double of all other maxima.

Let the waves from two coherent sources of light be represented as
$y_1 = a \sin\omega t$
$y_2 = b \sin(\omega t + \phi)$
where a and b are the respective amplitudes of the two waves and ϕ is the constant phase angle by which second wave leads the first wave.
According to superposition principle, the displacement (y) of the resultant wave at time (t) would be given by
$y = y_1 + y_2 = a \sin\omega t + b \sin(\omega t + \phi)$
$= a \sin\omega t + b \sin\omega t \cos\phi + b \cos\omega t \sin\phi$
$y = \sin\omega t\,(a + b\cos\phi) + \cos\omega t . b \sin\phi$
Put $a + b\cos\phi = R\cos\theta$ ...(i)
$b \sin\phi = R \sin\theta$ ...(ii)
$y = \sin\omega t . R\cos\theta + \cos\omega t . R\sin\theta$
$= R[\sin\omega t \cos\theta + \cos\omega t \sin\theta]$
$y = R\sin(\omega t + \theta)$
Thus the resultant wave is a harmonic wave of amplitude R.
Squaring equation (i) and (ii) and adding, we get
$R^2(\cos^2\theta + \sin^2\theta) = (a + b\cos\phi)^2 + (b\sin\phi)^2$
$R^2 \times 1 = a^2 + b^2\cos^2\phi + 2ab\cos\phi + b^2\sin^2\phi$
$= a^2 + b^2(\cos^2\phi + \sin^2\phi) + 2ab\cos\phi$

$$R = \sqrt{a^2 + b^2 + 2ab\cos\phi}$$

As intensity is directly proportional to the square of the amplitude of the wave
$\therefore \quad I_1 = Ka^2, I_2 = Kb^2,$
and $I_R = KR^2 = K(a^2 + b^2 + 2ab\cos\phi)$
$\therefore \quad I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$

41. *Refer to answer 31 (b).*



42. (a) *Refer to answer 31.*
(b) Since fringe width is give by $\beta = \dfrac{\lambda D}{d}$
(i) On increasing the width of slit d, the fringe width decreases.
(ii) On replacing monochromatic light with white light, the fringes of all colours will be overlapping in interference pattern.

43. (a) (i) Two independent monochromatic sources cannot produce sustained interference pattern because the phase difference between the light waves from two independent sources keeps on changing continuously.
(ii) *Refer to answer 31 (a).*
(b) *Refer to answer 34 (b).*

44. (a) *Refer to answer 35.*
(b) We have

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{9}$$