CHAPTER : 10

WAVE OPTICS

STUDY NOTES

- **Nature of light:** Wave nature of light could be established from the phenomena like interference, diffraction and polarisation, establish the wave nature of light where as the phenomena like black body radiation and photoelectric effect also establish the particle nature of light.

  Hence, de-Broglie proposed that light has a dual nature i.e., it can behave as particles as well as waves.
- **Wavefront:** It is the continuous locus of all such particles of the medium which are vibrating in the same phase at any instant. A point source generates spherical wavefronts, a linear source of light generates cylindrical wavefronts and sources present at a very large distances generates plane wavefront.
- **Ray:** It is an arrow drawn perpendicular to a wavefront in the direction of propagation of a wave.

  The principles valid for rays and wavefronts are:

  (i) Rays are normal to wavefronts

  (ii) The time taken to travel from one wavefront to another is the same along any ray.
- **Huygen's principle of secondary wavelets :** Huygen's principle describes how a wavefront propagates through a medium. It is based on the following assumptions :

  (i) Each point on a wavefront acts as a source of new disturbance called secondary waves or wavelets.

  (ii) The secondary wavelets spread out in all directions with the speed of light in the given medium.

  (iii) The wavefront at any later time is given by the forward envelope of the secondary wavelets at that time.
- **Effect on frequency, wavelength and speed during refraction :** Upon refraction, the frequency of light remains unchanged but both its wavelength and speed get changed, depending on the refractive index of the refracting medium.
- **Relation between Frequency and Speed :** The frequency remains the same as light travels from one medium to another. The speed v of a wave is given by $v = \lambda v$, where λ is the wavelength of the wave and v is the frequency.
- **Optical Path (d) :** It is defined as the distance which light travelling in a medium would have travelled in the same time if it were travelling in vacuum. It is given as the product of the geometric length of the optical path (D) followed by light and the refractive index (μ) of the medium through which a light ray propagates *i.e.*, $d = D\mu$
- **Principle of superposition:** According to principle of superposition, when two or more waves travel simultaneously in a medium, the resultant displacement at each point of the medium at any instant is equal to the vector sum of the displacements produced by the two waves separately.
- **Interference of light waves:** When light waves from two coherent sources travelling in the same direction superpose each other, the intensity in the region of superposition gets redistributed, becoming maximum at some points and minimum at others. This phenomenon is called interference of light.
- **Constructive and destructive interference:** If path difference $p = n\lambda$ or phase difference $\phi = 2n\pi$ the two waves are in same phase and so they create a bright fringe with maximum intensity. This is called constructive interference.
- If $p = \frac{(2n-1)\lambda}{2}$ or $\phi = (2n - 1)\pi$, the two superposing waves are out of phase, the resultant amplitude is equal to difference between their individual amplitudes and hence intensity is minimum resulting in dark fringe. This is called destructive interference.
- **Young's double slit experiment:** In Young's double slit experiment, a narrow source S is illuminated with monochromatic light and two identical narrow slits S_1 and S_2 are placed symmetrically with respect to S. The

interference pattern is obtained on a screen placed at large distance D from S_1 and S_2. The position of nth bright fringe from the centre of the screen is

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

- The position of nth dark fringe from the centre of the screen is

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

- **Fringe width:** It is the separation between two successive bright or dark fringes and is given by

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

- **Angular fringe width:** It is the angular distance between two consecutive fringes and is given by

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

- **Resultant amplitude and intensity of interfering waves:** Let a_1 and a_2 are the amplitudes and I_1 and I_2 are the intensities of two coherent waves having phase difference ϕ, then their resultant amplitude at the point of superposition are given by

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

and intensity at the point of superposition are given by

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

- If amplitude of each wave is a_0 and intensity I_0 then

$$I = 2I_0 + 2I_0\cos\phi = 2I_0(1+\cos\phi)$$

$$= 4I_0\cos^2\frac{\phi}{2}$$

The term $2\sqrt{I_1I_2}\cos\phi$ is called interference term.

(i) When $\cos\phi$ remains constant with time, the two sources are coherent. The intensity will be maximum at points for which $\cos\phi = 1$ and minimum at points for which $\cos\phi = -1$.

(ii) In incoherent sources, $\cos\phi$ varies continuously with time so its average value becomes zero over the time interval of measurement, and the resultant intensity at all points becomes $I_1 + I_2$. Hence, no interference fringes are observed.

- **Ratio of intensity at maxima and minima of an interference pattern:** If a_1 and a_2 are the amplitudes of two interfering waves, then the ratio between the intensities at maxima and minima will be

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

where, $r = \frac{a_1}{a_2} = \sqrt{\frac{I_1}{I_2}}$ is the amplitude ratio of two waves. If w_1 and w_2 are the widths of the two slits, then

$$\frac{w_1}{w_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$$

- **Coherent sources:** Two sources of light which continuously emit light waves of same frequency (or wavelength) with a zero or constant phase difference between them, are called coherent sources of light. Two independent sources of light cannot act as coherent sources, they have to be derived from the same parent source.
- **Conditions for sustained interference:**

(i) The two sources should continuously emit waves of same frequency or wavelength.

(ii) The two sources of light should be coherent.

(iii) The amplitudes of the interfering waves should be equal.

(iv) The two sources should be narrow.

(v) The interfering waves must travel nearly along the same direction.

(vi) The sources should be monochromatic.

(vii) The interfering waves should be in the same state of polarisation.

(viii) The distance between the two coherent sources should be small and the distance between the two sources and the screen should be large.

- **Diffraction of light :** The phenomenon of bending of light around the corners of small obstacles or apertures and their consequent spreading into the regions of geometrical shadow is called diffraction of light.
- **Diffraction at a single slit:** A plane wave of wavelength λ on passing through a narrow slit of width a suffers diffraction producing a central bright fringe ($\theta = 0°$), flanked on both sides by minima and maxima. The intensity of secondary maxima decreases with the increase in distance from the centre.
- For nth minimum :

$$a \sin \theta_n = n\lambda, \qquad n = 1, 2, 3, \ldots$$

- For nth secondary maximum :

$$a \sin \theta_n = (2n + 1)\frac{\lambda}{2}, \qquad n = 1, 2, 3, \ldots$$

- Angular position of nth minimum,

$$\theta_n = \frac{n\lambda}{a}$$

- Distance of nth minimum from the centre of the screen,

$$x_n = n\frac{D\lambda}{a}$$

- Angular position of nth secondary maximum

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

- Distance of nth secondary maximum from the centre of the screen,

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

- Width of a secondary maximum,

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

- Width of central maximum,

$$\beta_0 = 2\beta = \frac{2D\lambda}{a}$$

- Angular spread of central maximum on either side of the centre of the screen is

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

- Total angular spread of the central maximum is

$$2\theta = \frac{2\lambda}{a}$$

- For diffraction to be more pronounced, the size of the slit should be comparable to the wavelength of light used.

Rayleigh's criterion for resolution: The images of two point objects are just resolved when the central maximum of the diffraction pattern of one falls over the first minimum of the diffraction pattern of the other.

- **Resolving power (R.P) of a microscope:** It is given by:

$$\text{R.P. of a microscope} = \frac{1}{d} = \frac{2\mu \sin\theta}{\lambda}$$

Where θ is half the angle of cone of light from each point object and μ is the refractive index of the medium between the object and the objective. The factor μ sin θ is called numerical aperture (N.A.).

- **Resolving power(R.P) of a telescope.** It is given by:

$$\text{R.P. of a telescope} = \frac{1}{d\theta} = \frac{D}{1.22\,\lambda};$$

where D is the diameter of the telescope objective and λ is the wavelength of light used.

- **Resolving power of the human eye:** A human eye can see two point objects distinctly if they subtend at the eye, an angle equal to one minute of arc. This angle is called the limit of resolution of the eye. The reciprocal of this angle equals the resolving power of the eye.
- **Polarisation of waves:** A transverse wave in which the vibrations are present in just one direction in a plane perpendicular to the direction of propagation, the wave is said to be polarised or plane polarised. The phenomenon of restricting the oscillations of a wave to just one direction in the transverse plane is called polarisation.
- If the electric field vector of an em wave vibrates just in one direction that is perpendicular to the direction of wave propagation, the light is said to be linearly polarised. In a linearly polarised wave, the vibrations at all points, at all times, lie in the same plane, so it is also called a plane polarised wave.
- **Polariser:** A device that polarises the unpolarised light upon passing through it is called a polariser. For example, a tourmaline crystal, nicol prism, polaroid, etc.
- **Malus Law:** According to this law, when a beam of completely plane polarised light is passed through an analyser, the intensity 'I' of the transmitted light varies directly as the square of cosine of the angle 'θ' between the transmission directions of polariser and analyser.

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

where I_0 is the maximum intensity of transmitted light.

- **Plane of polarisation:** The plane that is perpendicular to the plane of vibration and is passing through the direction of wave propagation is called the plane of polarisation.
- **Brewster angle:** It is the angle of incidence at which a beam of unpolarised light falling on a transparent surface is reflected as a beam of completely plane polarised light. It is also called as polarising angle. It is denoted by i_p.
- **Brewster Law:** According to this law, the tangent of the polarising angle of incidence of a transparent medium is equal to its refractive index.

$$\mu = \tan i_p$$

- **Optical activity:** Substances which can rotate the plane of polarisation of light are called optically active substances while the phenomenon is called optical activity.
- **Specific rotation:** The angle through which the plane of polarisation rotates when plane polarised light is passed through one decimetre length of solution containing one gram of the substance per cm³ is called specific rotation. The measurement is done at a given temperature T, using sodium light (the D-line).

$$\text{Specific rotation} = \frac{\text{Observed angle of rotation in degrees}}{\text{Length of the tube in decimetre} \times \text{Gram of substance in 1 cm}^3\text{ of solution)}}$$

$$\text{or } [s]_D^T = \frac{\theta}{l \times c}$$

QUESTION BANK

MULTIPLE CHOICE QUESTIONS

1. The light waves from two coherent sources have same intensity $I_1 = I_2 = I_0$. In interference pattern the intensity of light at minima is zero. What will be the intensity of light at maxima?

(a) I_0 (b) $2\ I_0$ (c) $5\ I_0$ (d) $4\ I_0$

2. In Young's double slit experiment, if the source of light changes from orange to blue then :

(a) the central bright fringe will become a dark fringe
(b) the distance between consecutive fringes will decrease
(c) the distance between consecutive fringes will increase
(d) the intensity of the minima will increase

3. In the Young's double slit experiment, the distance between the slits varies in time as $d(t) = d_0 + a_0 \sin\omega t$; where d_0, ω and a_0 are constants. The difference between the largest fringe width and the smallest fringe width obtained over time is given as:

(a) $\dfrac{2\lambda D(d_0)}{\left(d_0^2 - a_0^2\right)}$ (b) $\dfrac{2\lambda D a_0}{\left(d_0^2 - a_0^2\right)}$ (c) $\dfrac{\lambda D}{d_0^2} a_0$ (d) $\dfrac{\lambda D}{d_0 + a_0}$

4. In Young's double slit arrangement, slits are separated by a gap of 0.5 mm, and the screen is placed at a distance of 0.5 m from them. The distance between the first and the third bright fringe formed when the slits are illuminated by a monochromatic light of 5890 angstrom is :-

(a) 1178×10^{-9}m (b) 1178×10^{-6}m (c) 1178×10^{-12}m (d) 5890×10^{-7}m

5. Consider the diffraction pattern obtained from the sunlight incident on a pinhole of diameter 0.1μm. If the diameter of the pinhole is slightly increased, it will affect the diffraction pattern such that:

(a) its size increases, but intensity decreases
(b) its size increases, and intensity increases
(c) its size decreases, but intensity increases
(d) its size decreases, and intensity decreases

6. Two coherent light sources having intensity in the ratio 2× produce an interference pattern. The ratio $\dfrac{I_{max} - I_{min}}{I_{max} + I_{min}}$ will be:

(a) $\dfrac{2\sqrt{2x}}{2x+1}$ (b) $\dfrac{2\sqrt{2x}}{x+1}$ (c) $\dfrac{\sqrt{2x}}{x+1}$ (d) $\dfrac{\sqrt{2x}}{2x+1}$

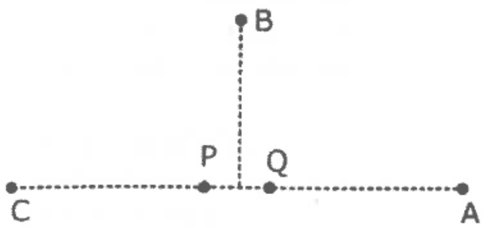
7. If the source of light used in a Young's double slit experiment is changed from red to violet

(a) the fringes will become brighter (b) the intensity of minima will increase
(c) consecutive fringe lines will come closer (d) the central fringe will become a dark fringe.

8. In a Young's double slit experiment, the width of the one of the slit is three times the other slit. The amplitude of the light coming from a slit is proportional to the slit-width. Find the ratio of the maximum to the minimum intensity in the interference pattern.

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

9. 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 90°. 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 :



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

10. 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 :

(a) $\frac{2\pi}{\lambda}(n_1L_1 - n_2L_2)$ (b) $\frac{2\pi}{\lambda}(n_2L_1 - n_1L_2)$ (c) $\frac{2\pi}{\lambda}(L_1/n_1 - L_2/n_2)$ (d) $\frac{2\pi}{\lambda}(L_2/n_1 - L_1/n_2)$

11. 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

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

12. In a Young's double slit experiment, 16 fringes are observed in a certain segment of the screen when light of a 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

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

13. 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 is

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

14. 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 3×10^{-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 :

(a) 1×10^{-5} J (b) 1×10^{-4} J (c) 1.5×10^{-4} J (d) 5.0×10^{-4} J

15. The aperture diameter of a telescope is 5 m. The separation between the moon and the earth is 4×10^5 km. With light of wavelength of 5500×10^{-10} m , the minimum separation between objects on the surface of moon, so that they are just resolved, is close to :

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

16. Visible light of wavelength 6000×10^{-8} cm falls normally on a single slit and produces a diffraction pattern. It is found that the second diffraction minimum is at 60° from the central maximum. If the first minimum is produced at θ_2 then θ_1, is close to :

(a) 45° (b) 30° (c) 25° (d) 20°

17. In diffraction pattern :

(a) The fringe width are equal (b) The fringe widths are not equal
(c) The fringe cannot be produced (d) The fringe width may or may not be equal.

18. In studying diffraction pattern of different obstacles, the effect of :

(a) full wave front is studied (b) portion of a wave front is studied
(c) waves from two coherent sources is studied (d) waves from one of the coherent source is studied.

19. 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 :

(a) 71.6° (b) 90° (c) 18.4° (d) 45°

20. 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_0 is incident on P_1, the intensity of light transmitted by the three polarizers is I. The ratio (I_0/I)) equals (nearly):

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

21. 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 (λ is the wavelength of the light used) :

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

22. To observe diffraction, the size of an obstacle:

(a) should be of the same order as the wavelength
(b) should be much larger than the wavelength
(c) has no relation to wavelength
(d) may be greater or smaller than the wavelength

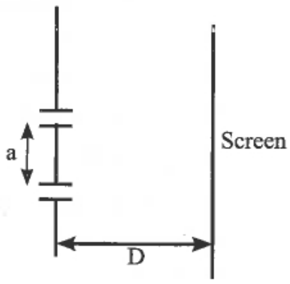
23. A beam of unpolarized light is passed first through a tourmaline crystal A and then through another tourmaline crystal B oriented so that its principal plane is parallel to that of A. The intensity of final emergent light is I. If A is rotated by 45° on a plane, perpendicular to the direction of incident ray, then intensity of emergent light will be

(a) 1/8 (b) 1/4 (c) 1/2 (d) none of these

24. If $f_0 = 5$ cm, $\lambda = 600$ Å, $a = 1$ cm for a microscope , then that will be its resolving power.

(a) 11.9×10^6/m (b) 10.9×10^5/m (c) 10.9×10^4/m (d) 10.9×10^3/m

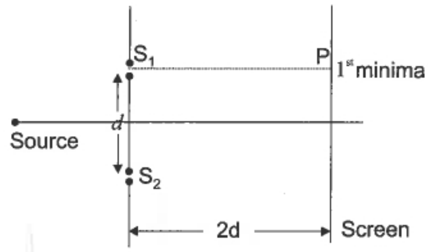
25. The figure shows a Young's double slit experimental setup. It is observed that when a thin transparent sheet of thickness t and refractive index μ is put in front of one of the slits, the central maximum gets shifted by a distance equal to n fringe widths. If the wavelength of light used is λ, t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



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

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

26. 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)?



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

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

27. In a Young's double slit experiment, the slits are placed 0.320 mm apart. Light of wavelength $\lambda = 500$ 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 :

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

28. 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 :

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

29. In a single slit diffraction with $\lambda = 500$nm and a lens of diameter 0.1mm, width of central maxima, obtain on screen at a distance of 1 m will be

(a) 5 mm (b) 1 mm (c) 10 mm (d) 2.5 mm

30. Two light waves follow principle of superposition. They are represented by $y_1 = A \sin \omega t$ and $y_2 = A\sin(\omega t + \delta)$. The phase of the resultant wave is:

(a) 2δ (b) $\frac{\delta}{2}$ (c) $\frac{\delta}{3}$ (c) $\frac{\delta}{4}$

31. Huygen's wave theory of light cannot explain

(a) diffraction (b) interference (c) polarization (d) photoelectric

32. Light waves travel in vacuum along the y-axis. Then the wavefront

(a) y = constant (b) x = constant (c) z = constant (d) $x + y + z$ = constant

33. The plane of a wavefront of light wave travelling in vacuum are given by $3x + y + z = 5$. The angle made by the light ray with the x- axis is :

(a) 0° (b) 45° (c) 90° (d) $\cos^{-1}\left(\frac{\sqrt{3}}{\sqrt{5}}\right)$

34. On a hot summer night, the refractive index of air is smallest near the ground and increase with height from the ground. When a light beam is directed horizontally, the Huygen's principle leads us to conclude that as it travels, the light beam

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

35. Following statements which are true for light waves but not for sound waves are/is

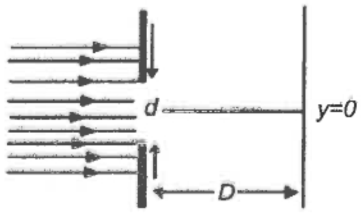
(I) The speed of waves is greater in vacuum than in a medium.
(II) Waves of different frequencies travel with different speeds in a medium.
(III) Waves travel with different speeds in different media.

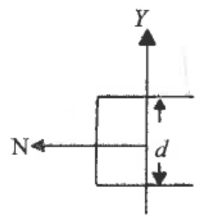
(a) (I) only (b) (I) and (III) (c) (II) and (III) (d) (I), (II) and (III)

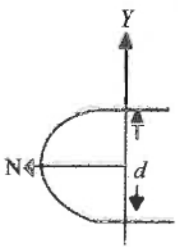
36. A beam of light of wavelength 600 nm from a distant source falls on a single slit 1.00 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between the first dark fringe on either side of the central maxima is:

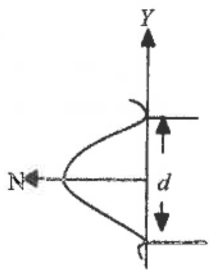
(a) 1.2 cm (b) 1.2 mm (c) 2.4 mm (d) 4.8 mm

37. In an electron 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. Which of the following graphs can be expected to represent the numbers of electron N detected as a function of the detector position y ($y = 0$) corresponds to the middle of the slit)?

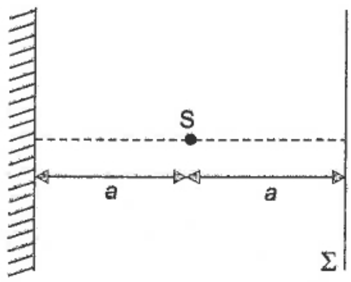
(a)


(b)


(c)


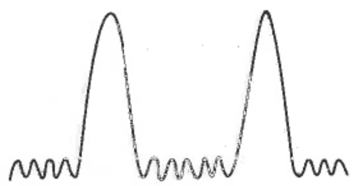
(d)


38. During an experiment a point source of light S is kept in front of a perfectly reflecting mirror as shown in the figure. Σ is a screen. The intensity at the centre of screen was found to be I.If the mirror is removed, then the intensity at the centrr of screen will be



(a) I (b) I/9 (c) 9I/10 (d) 2I

39. The figure shows diffraction pattern of two nearby points. The two points are

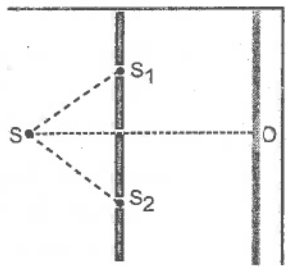


(a) not resolved
(b) just resolved
(c) clearly resolved
(d) none of these

40. Due to some damage to the petrol tank of a truck, few drops of petrol fell over rainwater on the surface of the road.Colours are seen on the surface, this is due to

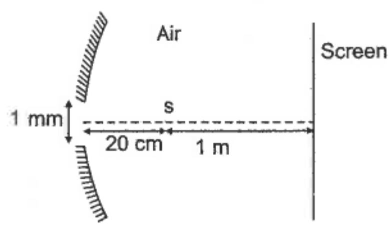
(a) dispersion of light (b) interference of light (c) scattering of light (d) absorption of light

41. A set up as shown in the figure is made by a demonstrator. The slit S is movable and its position can be changed. Currently, the two slits are S_1 and S_2 are not equidistant from the slit S. Then, at the centre O, the demonstrator will observe



(a) always bright
(b) always dark
(c) either dark or bright depending on the position of S
(d) neither dark nor bright

42. An arrangement of mirror, source and screen is made as shown in figure. If half of the reflecting surface of upper part of the mirror is painted black. Which of the following options is correct?



(a) Intensity of maxima and minima will increase
(b) Intensity at minima will increase and at maxima, intensity will decrease
(c) Intensity at minima will remain zero and at maxima,intensity will decrease
(d) Intersity at maxima remains unchanged but at minima, intensity will increase

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

(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) $\frac{I_m}{9}\left(1 + 8\cos^2\frac{\phi}{2}\right)$

44. In the Young's double slit experiment, the resultant intensity at a point on the screen is 75% of the maximum intensity of the bright fringe. The phase difference between the two interfering rays at that point is:

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

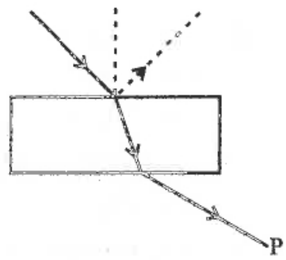
45. The Brewster's angle i_b for an interface should be:

(a) $30° < i_b < 45°$ (b) $45° < i_b < 90°$ (c) $i_b = 90°$ (d) $0° < i_b < 30°$

46. A light ray strikes a glass plate at an angle of 60°. If the angle between the reflected and refracted ray is 90°, then the index of refraction of glass is

(a) $\frac{1}{2}$ (b) $\frac{\sqrt{3}}{2}$ (c) $\frac{3}{2}$ (d) 1.732

47. Consider a light beam incident from air to a glass slab at Brewster's angle as shown in figure. A polaroid is placed in the path of the emergent ray at point P and rotated about an axis passing through the centre and perpendicular to the plane of the polaroid.

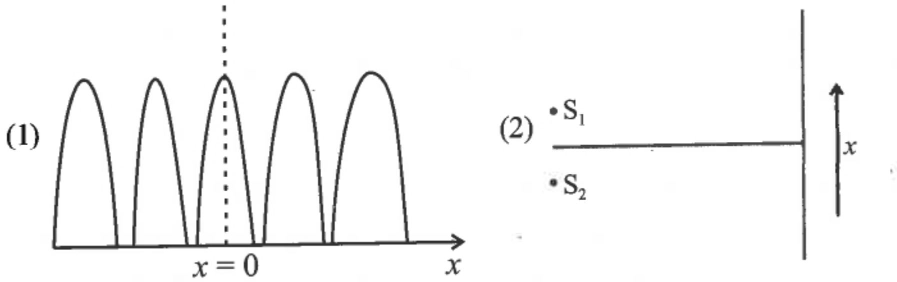


(a) For a particular orientation, there shall be darkness as observed through the polaroid
(b) The intensity of light as seen through the polaroid shall be independent of the rotation
(c) The intensity of light as seen through the polaroid shall go through a minimum but not zero for two orientations of the polaroid
(d) The intensity of light as seen through the polaroid shall go through a minimum for four orientations of the polaroid

48. In a house,sunlight passes through a small hole which is similar to a slit of width 10^4 Å. The image seen through the slit shall
(a) be a fine sharp slit white in colour at the centre
(b) a bright slit white at the centre diffusing to zero intensities at the edges
(c) a bright slit white at the centre diffusing to regions of different colours
(d) only be a diffused slit white in colour

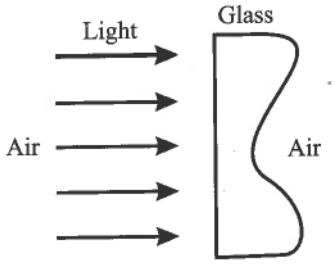
49. In Young's double-slit experiment, white light is used as source. One of the slit is covered by a red filter and another by a blue filter. In this case,
(a) there shall be alternate interference patterns of red and blue
(b) there shall be an interference pattern for red distinct from that for blue
(c) there shall be no interference fringes
(d) there shall be an interference pattern for red mixing with one for blue

50. A pattern of intensity distribution as shown in figure (1) seen in the central portion. Let this pattern formed by two sources S_1 and S_2 of intensity I_1 and I_2 are placed infront of a screen as shown in figure (2). In this case, which statement is incorrect?



(a) S_1 and S_2 have the same intensities.
(b) S_1 and S_2 have a constant phase difference.
(c) S_1 and S_2 have the same phase.
(d) S_1 and S_2 have the same wavelength.

51. A parallel beam of light strikes a piece of transparent glass having a cross section as shown in the figure below. Correct shape of the emergent wavefront will be (figures are schematic and not drawn to scale)



52. In a double slit experiment, sodium light of wavelength 589 nm produces fringes spaced 1.8 mm on a screen. If the source is replaced by another one of wavelength 436 nm the fringe spacing is:
(a) 1.33 mm (b) 2.3 mm (c) 0.33 mm (d) 2 mm

53. Wavefront is the locus of all points, where the particles of the medium vibrate with the same
(a) phase (b) frequency (c) amplitude (d) period

54. The wavelength of the light used in Young's double experiment is λ. The intensity at a point on the screen is I, where the path difference is $\lambda/6$. If I_0 denotes the maximum intensity, then the ratio of I and I_0 is
(a) 0.866 (b) 0.5 (c) 0.707 (d) 0.75

55. If the ratio of maximum and minimum intensities of an interference pattern is 36:1, then the ratio of amplitudes of the two interfering waves will be
(a) 3:7 (b) 7:4 (c) 4:7 (d) 7:5

56. A Young's double slit set up for interference is shifted from air to within water, then the fringe width
(a) becomes infinite (b) decreases (c) increases (d) remain unchanged

57. A parallel beam of light of wavelength 6000 Å gets diffracted by a single slit of width 0.3 mm. The angular position of the first minima of diffracted light is
(a) 2×10^{-3} rad (b) 3×10^{-3} rad
(c) 1.8×10^{-3} rad (d) 6×10^{-3} rad

58. If two sources have a randomly varying phase difference $\phi(t)$, the resultant intensity will be given by (here I_0 is the intensity of each source)
(a) $1/2I_0$ (b) $I_0/2$ (c) $2I_0$ (d) $I_0/\sqrt{2}$

59. Consider the following statements in case of Young's double slit experiment
(1) A slit S is necessary if we use an ordinary extended source of light.
(2) A slit S is not needed if we use an ordinary but well collimated beam of light.
(3) A slit S is not needed if we use a spatially coherent source of light.

Which of the above statements are correct?
(a) (1), (2) and (3) (b) (1) and (2) (c) (3) and (2) (d) (1) and (3)

60. In a single slit diffraction experiment, the width of the slit is made double its original width. Then the central maximum on the diffraction pattern will become
(a) narrower and fainter (b) narrower and brighter
(c) broader and fainter (d) broader and brighter

61. **Assertion :** The clouds in sky generally appear to be whitish.
Reason : Diffraction due to clouds is efficient in equal measure at all wavelengths.
(a) If both assertion and reason are true and the reason is the correct explanation of the assertion
(b) If both assertion and reason are true but the reason is not the correct explanation of the assertion
(c) If assertion is true but reason is false
(d) If both assertion and reason are true

62. Transverse nature phenomenon of light was confirmed by the
(a) refraction of light (b) diffraction of light (c) dispersion of light (d) polarization of light

63. Young's experiment is performed with light of wavelength 6000 Å where 16 fringes occupy a certain region on the screen. If 24 fringes occupy the same region with another light, of wavelength λ, then λ is
(a) 6000 Å (b) 4500 Å (c) 5000 Å (d) 4000 Å

64. The intensity at the central maxima (O) in a Young's double slit set up is I_0. If the distance OP equals one third of the fringe width of the pattern. What is the intensity at point P?

(a) $I_0/3$ (b) $I_0/4$
(c) $2I_0$ (d) I_0

65. When ordinary light is made incident on a quarter wave plate, the emergent light is
(a) linearly polarised (b) circularly polarised (c) elliptically polarised (d) unpolarised.

66. Angular width of central maximum in the Fraunhoffer's diffraction pattern is measured. Slit is illuminated by the light of wavelength 6000 angstrom. If slit is illuminated by light of another wavelength, angular width decreases by 30%. Wavelength of light used is:
(a) 3500 angstrom (b) 4200 angstrom (c) 4700 angstrom (d) 6000 angstrom

67. Angular width (θ) of central maximum of a diffraction pattern of a single slit does not depend upon

(a) distance between slit and screen (b) wavelength of light used

(c) width of the slit (d) frequency of light used

68. Bright colours exhibited by spider's web,exposed to sunlight are due to

(a) diffraction (b) interference (c) polarisation (d) resolution.

69. The two slits at a distance of 1 mm are illuminated by the light of wavelength 6.5×10^{-7} m. The interference fringes are observed on a screen placed at a distance of 1 m. The distance between third dark fringe and fifth bright fringe will be

(a) 0.65 cm (b) 4.8 mm (c) 1.63 mm (d) 3.25 cm

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

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

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

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

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

71. At the first minimum adjacent to the central maximum of a single-slit diffraction pattern the phase difference between the Huygen's wavelet from the edge of the slit and the wavelet from the midpoint of the slit is

(a) $\frac{\pi}{8}$ (b) $\frac{\pi}{4}$ (c) $\frac{\pi}{2}$ (d) π

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

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

73. Young's double slit experiment is performed with blue and with green light of wavelength 4360 Å and 5460 Å respectively. If X is the distance of 4th maximum from the central one, then

(a) X (blue) = X (green) (b) X (blue) > X (green)

(c) X (blue) < X (green) (d) X (blue) / X (green)

74. **Assertion.** Static crashes are heard on radio, when lightning flash occurs in the sky.

Reason. Electromagnetic waves having frequency of radiowave range, interfere with radiowaves.

(a) If both assertion and reason are true and reason is the correct explanation of assertion

(b) If both assertion and reason are true but reason is not the correct explanation of assertion

(c) If assertion is true but reason is false

(d) If both assertion and reason are false.

75. Which out of following, cannot produce two coherent sources?

(a) Lloyd's mirror (b) Fresnel briprism (c) Young's double slit (d) Prism

76. The resolving power of a reflecting telescope depends

(a) on the intensity of light used (b) directly on wavelength of the light used

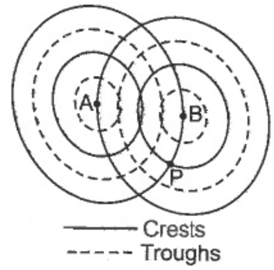
(c) on the focal length of objective lens (d) directly on the diameter of objective lens

77. A laser beam is used for locating distant objects because

(a) it is monochromatic (b) it is coherent

(c) it is not absorbed (d) it has small angular spread.

78. The diagram below shows two sources, A and B. vibrating in phase in the same uniform medium and producing circular wave fronts.

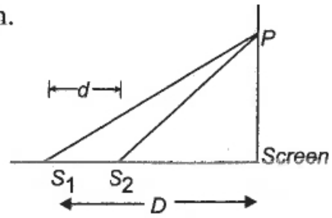


Which phenomenon occurs at point P?

(a) Destructive interference (b) Constructive interference

(c) Reflection (d) Refraction

79. 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

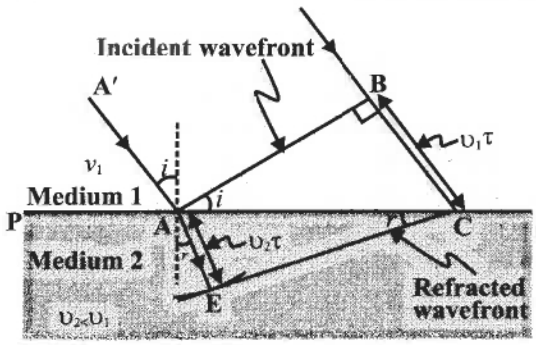


(a) points (b) straight lines
(c) semicircles (d) concentric circles

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

INPUT TEXT BASED MCQs

1. *The figure given below show refraction of a plane wave.*
Let PP' represent the surface separating medium 1 and medium 2, as shown in Figure. Let v_1 and v_2 represent 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 as shown in the figure. Let τ be the time taken by the wavefront to travel the distance BC.



(i) What is the angle made by the ray of light on the wavefront?
(a) 90° (b) 0°
(c) 45° (d) None of these

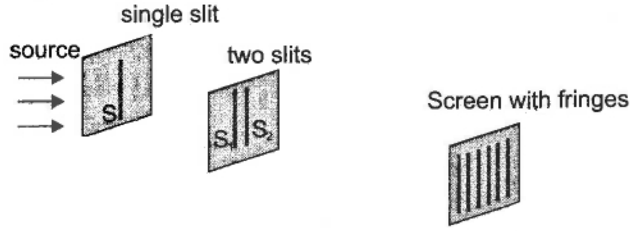
(ii) Which parameter remains unchanged while a ray of light propagates from one medium to another?
(a) velocity (b) wavelength (c) frequency (d) None of these

(iii) According to the above given fig. idenfity the correct expression for Snell's law.
(a) $n_1 \sin i = n_2 \sin r$ (b) $n_2 \sin i = n_1 \sin r$ (c) $n_{21} \sin r / \sin i$ (d) None of these

(iv) When a ray of light travels from a denser to a rarer medium, it
(a) bends towards the normal
(b) travels in a straight line irrespective of angle of incidence
(c) bends away from the normal
(d) None of these

(v) Light travells faster in air than that in glass. This is accordance with
(a) wave theory of light (b) Corpuscular theory of light
(c) both (a) and (b) (d) neither (a) nor (b)

2. The British physicist Thomas Young used an ingenious technique to "lock" the phases of the waves emanating from S_1 and S_2. He made two pinholes S_1 and S_2 (very close to each other) on an opaque screen (as shown in figure). These were illuminated by another pinholes that was in turn, lit by a bright source. Light waves spread out from S and fall on both S_1 and S_2.



(i) What is the path difference between the two light waves coming from coherent sources, which produces 3rd maxima?
(a) λ (b) 2 λ (c) 3 λ (d) 0

(ii) What is the correct expression for fringe width (β)?

(a) λd/D (b) λdD (c) d/λD (d) λD/d

(iii) What is the phase difference between two interfering waves producing 1st dark fringe?

(a) π (b) 2π (c) 3π (d) 4π

(iv) The ratio of the width of two slits in Young's double slit experiment is 4:1. Evaluate the ratio of intensites at maxima and minima in the interference pattern.

(a) 1:1 (b) 1:4 (c) 3:1 (d) 9:1

(v) In a Young's double slits experiment the separation between the slits is 0.1 mm, the wavelength of light used is 600 nm and the interence pattern is observed on a screen 1 m away. Find the separation between bright finges.

(a) 6.6 mm (b) 6.0 mm (c) 6 m (d) 60 cm

ANSWERS

1. (d)	**2.** (b)	**3.** (a)	**4.** (c)	**5.** (c)	**6.** (a)	**7.** (c)	**8.** (a)	**9.** (b)	**10.** (a)
11. (c)	**12.** (a)	**13.** (a)	**14.** (b)	**15.** (d)	**16.** (c)	**17.** (b)	**18.** (b)	**19.** (a)	**20.** (a)
21. (d)	**22.** (a)	**23.** (c)	**24.** (b)	**25.** (d)	**26.** (b)	**27.** (d)	**28.** (b)	**29.** (c)	**30.** (b)
31. (d)	**32.** (a)	**33.** (d)	**34.** (d)	**35.** (a)	**36.** (c)	**37.** (c)	**38.** (c)	**39.** (c)	**40.** (b)
41. (c)	**42.** (b)	**43.** (d)	**44.** (c)	**45.** (b)	**46.** (d)	**47.** (c)	**48.** (a)	**49.** (c)	**50.** (c)
51. (a)	**52.** (a)	**53.** (a)	**54.** (d)	**55.** (d)	**56.** (b)	**57.** (a)	**58.** (c)	**59.** (a)	**60.** (b)
61. (d)	**62.** (d)	**63.** (d)	**64.** (b)	**65.** (d)	**66.** (b)	**67.** (a)	**68.** (b)	**69.** (c)	**70.** (c)
71. (d)	**72.** (c)	**73.** (c)	**74.** (a)	**75.** (d)	**76.** (d)	**77.** (d)	**78.** (b)	**79.** (d)	**80.** (c)

Input Text Based MCQs

1. (i) (a), (ii) (c), (iii) (a), (iv) (c), (v) (a) **2.** (i) (c), (ii) (d), (iii) (a), (iv) (d), (v) (b)