CHAPTER 10

# Wave Optics

## 10.1 Introduction

1. Which one of the following phenomena is not explained by Huygen's construction of wavefront ?
(a) Refraction (b) Reflection
(c) Diffraction (d) Origin of spectra
*(1988)*

## 10.3 Refraction and Reflection of Plane Waves using Huygens Principle

2. The frequency of a light wave in a material is $2 \times 10^{14}$ Hz and wavelength is 5000 Å. The refractive index of material will be
(a) 1.50 (b) 3.00
(c) 1.33 (d) 1.40 *(2007)*

3. An electromagnetic radiation of frequency $n$, wavelength $\lambda$, travelling with velocity $v$ in air, enters a glass slab of refractive index $\mu$. The frequency, wavelength and velocity of light in the glass slab will be respectively
(a) $n, 2\lambda$ and $\frac{v}{\mu}$ (b) $\frac{2n}{\mu}, \frac{\lambda}{\mu}$ and $v$
(c) $\frac{n}{\mu}, \frac{\lambda}{\mu}$ and $\frac{v}{\mu}$ (d) $n, \frac{\lambda}{\mu}$ and $\frac{v}{\mu}$ *(1997)*

4. The refractive index of water is 1.33. What will be the speed of light in water?
(a) $4 \times 10^8$ m/s (b) $1.33 \times 10^8$ m/s
(c) $3 \times 10^8$ m/s (d) $2.25 \times 10^8$ m/s *(1996)*

5. Light travels through a glass plate of thickness $t$ and having a refractive index $\mu$. If $c$ is the velocity of light in vacuum, the time taken by light to travel this thickness of glass is
(a) $\frac{t}{\mu c}$ (b) $\frac{\mu t}{c}$ (c) $t\mu c$ (d) $\frac{tc}{\mu}$ *(1996)*

6. A star, which is emitting radiation at a wavelength of 5000 Å, is approaching the earth with a velocity of $1.5 \times 10^4$ m/s. The change in wavelength of the radiation as received on the earth is
(a) 25 Å (b) 100 Å
(c) zero (d) 2.5 Å *(1995)*

7. Time taken by sunlight to pass through a window of thickness 4 mm whose refractive index is $\frac{3}{2}$ is
(a) $2 \times 10^{-4}$ s (b) $2 \times 10^8$ s
(c) $2 \times 10^{-11}$ s (d) $2 \times 10^{11}$ s *(1993)*

8. A beam of monochromatic light is refracted from vacuum into a medium of refractive index 1.5. The wavelength of refracted light will be
(a) depend on intensity of refracted light
(b) same
(c) smaller (d) larger. *(1992, 1991)*

9. Green light of wavelength 5460 Å is incident on an air-glass interface. If the refractive index of glass is 1.5, the wavelength of light in glass would be ($c = 3 \times 10^8$ m s$^{-1}$)
(a) 3640 Å (b) 5460 Å
(c) 4861 Å (d) none of these. *(1991)*

## 10.4 Coherent and Incoherent Addition of Waves

10. The interference pattern is obtained with two coherent light sources of intensity ratio $n$. In the interference pattern, the ratio $\frac{I_{max} - I_{min}}{I_{max} + I_{min}}$ will be
(a) $\frac{\sqrt{n}}{n+1}$ (b) $\frac{2\sqrt{n}}{n+1}$ (c) $\frac{\sqrt{n}}{(n+1)^2}$ (d) $\frac{2\sqrt{n}}{(n+1)^2}$
*(NEET-II 2016)*

11. Ratio of intensities of two waves are given by 4 : 1. Then ratio of the amplitudes of the two waves is
(a) 2 : 1 (b) 1 : 2
(c) 4 : 1 (d) 1 : 4 *(1991)*

12. Interference is possible in
(a) light waves only (b) sound waves only
(c) both light and sound waves
(d) neither light nor sound waves. *(1989)*

## 10.5 Interference of Light Waves and Young's Experiment

**13.** In Young's double slit experiment, if the separation between coherent sources is halved and the distance of the screen from the coherent sources is doubled, then the fringe width becomes
(a) double (b) half
(c) four times (d) one-fourth
*(NEET 2020)*

**14.** In a double slit experiment, when light of wavelength 400 nm was used, the angular width of the first minima formed on a screen placed 1 m away, was found to be 0.2°. What will be the angular width of the first minima, if the entire experimental apparatus is immersed in water? ($\mu_{water} = 4/3$)
(a) 0.1° (b) 0.266° (c) 0.15° (d) 0.05°
*(NEET 2019)*

**15.** In a Young' double slit experiment if there is no initial phase difference between the light from the two slits, a point on the screen corresponding to the fifth minimum has path difference.
(a) $5\frac{\lambda}{2}$ (b) $10\frac{\lambda}{2}$ (c) $9\frac{\lambda}{2}$ (d) $11\frac{\lambda}{2}$
*(Odisha NEET 2019)*

**16.** In Young's double slit experiment the separation $d$ between the slits is 2 mm, the wavelength $\lambda$ of the light used is 5896 Å and distance $D$ between the screen and slits is 100 cm. It is found that the angular width of the fringes is 0.20°. To increase the fringe angular width to 0.21° (with same $\lambda$ and $D$) the separation between the slits needs to be changed to
(a) 1.8 mm (b) 1.9 mm
(c) 2.1 mm (d) 1.7 mm *(NEET 2018)*

**17.** Young's double slit experiment is first performed in air and then in a medium other than air. It is found that $8^{th}$ bright fringe in the medium lies where $5^{th}$ dark fringe lies in air. The refractive index of the medium is nearly
(a) 1.59 (b) 1.69 (c) 1.78 (d) 1.25
*(NEET 2017)*

**18.** The intensity at the maximum in a Young's double slit experiment is $I_0$. Distance between two slits is $d = 5\lambda$, where $\lambda$ is the wavelength of light used in the experiment. What will be the intensity in front of one of the slits on the screen placed at a distance $D = 10d$?
(a) $\frac{3}{4}I_0$ (b) $\frac{I_0}{2}$ (c) $I_0$ (d) $\frac{I_0}{4}$
*(NEET-I 2016)*

**19.** Two slits in Young's experiment have widths in the ratio 1 : 25. The ratio of intensity at the maxima and minima in the interference pattern, $\frac{I_{max}}{I_{min}}$ is
(a) $\frac{49}{121}$ (b) $\frac{4}{9}$ (c) $\frac{9}{4}$ (d) $\frac{121}{49}$
*(2015)*

**20.** In the Young's double slit experiment, the intensity of light at a point on the screen where the path difference $\lambda$ is $K$, ($\lambda$ 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 *(2014)*

**21.** In Young's double slit experiment, the slits are 2 mm apart and are illuminated by photons of two wavelengths $\lambda_1 = 12000$ Å and $\lambda_2 = 10000$ Å. At what minimum distance from the common central bright fringe on the screen 2 m from the slit will a bright fringe from one interference pattern coincide with a bright fringe from the other?
(a) 4 mm (b) 3 mm
(c) 8 mm (d) 6 mm *(NEET 2013)*

**22.** In Young's double slit experiment the distance between the slits and the screen is doubled. The separation between the slits is reduced to half. As a result the fringe width
(a) is halved
(b) becomes four times
(c) remains unchanged
(d) is doubled. *(Karnataka NEET 2013)*

**23.** Colours appear on a thin soap film and on soap bubbles due to the phenomenon of
(a) interference (b) dispersion
(c) refraction (d) diffraction. *(1999)*

**24.** In a Fresnel biprism experiment, the two positions of lens give separation between the slits as 16 cm and 9 cm respectively. What is the actual distance of separation?
(a) 13 cm (b) 14 cm
(c) 12.5 cm (d) 12 cm *(1995)*

**25.** Interference was observed in interference chamber where air was present, now the chamber is evacuated, and if the same light is used, a careful observer will see
(a) no interference
(b) interference with brighter bands
(c) interference with dark bands
(d) interference with larger width. *(1993)*

**26.** If yellow light emitted by sodium lamp in Young's double slit experiment is replaced by monochromatic blue light of the same intensity
(a) fringe width will decrease
(b) fringe width will increase
(c) fringe width will remain unchanged
(d) fringes will becomes less intense *(1992)*

**27.** In Young's double slit experiment carried out with light of wavelength ($\lambda$) = 5000 Å, the distance between the slits is 0.2 mm and the screen is at 200 cm from the slits. The central maximum is at $x$ = 0. The third maximum (taking the central maximum as zeroth maximum) will be at $x$ equal to
(a) 1.67 cm (b) 1.5 cm
(c) 0.5 cm (d) 5.0 cm *(1992)*

**28.** In Young's experiment, two coherent sources are placed 0.90 mm apart and fringes are observed one metre away. If it produces second dark fringe at a distance of 1 mm from central fringe, the wavelength of monochromatic light is used would be
(a) $60 \times 10^{-4}$ cm (b) $10 \times 10^{-4}$ cm
(c) $10 \times 10^{-5}$ cm (d) $6 \times 10^{-5}$ cm *(1991)*

**29.** In Young's double slit experiment, the fringes width is found to be 0.4 mm. If the whole apparatus is immersed in water of refractive index $\frac{4}{3}$, without disturbing the geometrical arrangement, the new fringe width will be
(a) 0.30 mm (b) 0.40 mm
(c) 0.53 mm (d) 450 micron. *(1990)*

**30.** The Young's double slit experiment is performed with blue and with green light of wavelengths 4360 Å and 5460 Å respectively. If $x$ is the distance of 4$^{th}$ maxima from the central one, then
(a) $x$(blue) = $x$(green) (b) $x$(blue) > $x$(green)
(c) $x$(blue) < $x$(green) (d) $\frac{x(\text{blue})}{x(\text{green})} = \frac{5460}{4360}$
*(1990)*

## 10.6 Diffraction

**31.** Assume that light of wavelength 600 nm is coming from a star. The limit of resolution of telescope whose objective has a diameter of 2 m is
(a) $3.66 \times 10^{-7}$ rad (b) $1.83 \times 10^{-7}$ rad
(c) $7.32 \times 10^{-7}$ rad (d) $6.00 \times 10^{-7}$ rad
*(NEET 2020)*

**32.** An astronomical refracting telescope will have large angular magnification and high angular resolution, when it has an objective lens of
(a) small focal length and large diameter
(b) large focal length and small diameter
(c) large focal length and large diameter
(d) small focal length and small diameter.
*(NEET 2018)*

**33.** The ratio of resolving powers of an optical microscope for two wavelengths $\lambda_1$ = 4000 Å and $\lambda_2$ = 6000 Å is
(a) 9 : 4 (b) 3 : 2
(c) 16 : 81 (d) 8 : 27 *(NEET 2017)*

**34.** A linear aperture whose width is 0.02 cm is placed immediately in front of a lens of focal length 60 cm. The aperture is illuminated normally by a parallel beam of wavelength $5 \times 10^{-5}$ cm. The distance of the first dark band of the diffraction pattern from the centre of the screen is
(a) 0.10 cm (b) 0.25 cm
(c) 0.20 cm (d) 0.15 cm
*(NEET-II 2016)*

**35.** In a diffraction pattern due to a single slit of width $a$, the first minimum is observed at an angle 30° when light of wavelength 5000 Å is incident on the slit. The first secondary maximum is observed at an angle of
(a) $\sin^{-1}\left(\frac{1}{2}\right)$ (b) $\sin^{-1}\left(\frac{3}{4}\right)$
(c) $\sin^{-1}\left(\frac{1}{4}\right)$ (d) $\sin^{-1}\left(\frac{2}{3}\right)$
*(NEET-I 2016)*

**36.** In a double slit experiment, the two slits are 1 mm apart and the screen is placed 1 m away. A monochromatic light of wavelength 500 nm is used. What will be the width of each slit for obtaining ten maxima of double slit within the central maxima of single slit pattern?
(a) 0.5 mm (b) 0.02 mm
(c) 0.2 mm (d) 0.1 mm
*(2015 Cancelled)*

**37.** 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) $\pi$ radian (b) $\frac{\pi}{8}$ radian
(c) $\frac{\pi}{4}$ radian (d) $\frac{\pi}{2}$ radian *(2015)*

**38.** A beam of light of $\lambda$ = 600 nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between first dark fringes on either side of the central bright fringe is
(a) 1.2 cm (b) 1.2 mm
(c) 2.4 cm (d) 2.4 mm *(2014)*

**39.** A parallel beam of fast moving electrons is incident normally on a narrow slit. A fluorescent screen 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) The angular width of the central maximum will decrease.
(b) The angular width of the central maximum will be unaffected.
(c) Diffraction pattern is not observed on the screen in the case of electrons.
(d) The angular width of the central maximum of the diffraction pattern will increase.
*(NEET 2013)*

**40.** A parallel beam of light of wavelength $\lambda$ is incident normally on a narrow slit. A diffraction pattern formed on a screen placed perpendicular to the direction of the incident beam. At the second minimum of the diffraction pattern, the phase difference between the rays coming from the two edges of slit is
(a) $2\pi$ (b) $3\pi$ (c) $4\pi$ (d) $\pi\lambda$
*(Karnataka NEET 2013)*

**41.** The angular resolution of a 10 cm diameter telescope at a wavelength of 5000 Å is of the order of
(a) $10^6$ rad (b) $10^{-2}$ rad
(c) $10^{-4}$ rad (d) $10^{-6}$ rad *(2005)*

**42.** A telescope has an objective lens of 10 cm diameter and is situated at a distance of one kilometre from two objects. The minimum distance between these two objects, which can be resolved by the telescope, when the mean wavelength of light is 5000 Å, is of the order of
(a) 0.5 m (b) 5 m
(c) 5 mm (d) 5 cm *(2004)*

**43.** Diameter of human eye lens is 2 mm. What will be the minimum distance between two points to resolve them, which are situated at a distance of 50 meter from eye? (The wavelength of light is 5000 Å.)
(a) 2.32 m (b) 4.28 mm
(c) 1.25 cm (d) 12.48 cm *(2002)*

**44.** Ray optics is valid, when characteristic dimensions are
(a) much smaller than the wavelength of light
(b) of the same order as the wavelength of light
(c) of the order of one millimetre
(d) much larger than the wavelength of light.
*(1994, 1989)*

**45.** A parallel beam of monochromatic light of wavelength 5000 Å is incident normally on a single narrow slit of width 0.001 mm. The light is focussed by a convex lens on a screen placed in focal plane. The first minimum will be formed for the angle of diffraction equal to
(a) 0° (b) 15° (c) 30° (d) 50°
*(1993)*

## 10.7 Polarisation

**46.** The Brewsters angle $i_b$ for an interface should be
(a) $0° < i_b < 30°$ (b) $30° < i_b < 45°$
(c) $45° < i_b < 90°$ (d) $i_b = 90°$ *(NEET 2020)*

**47.** Unpolarised light is incident from air on a plane surface of a material of refractive index $\mu$. At a particular angle of incidence $i$, it is found that the reflected and refracted rays are perpendicular to each other. Which of the following options is correct for this situation?
(a) Reflected light is polarised with its electric vector parallel to the plane of incidence.
(b) Reflected light is polarised with its electric vector perpendicular to the plane of incidence.
(c) $i = \sin^{-1}\left(\frac{1}{\mu}\right)$ (d) $i = \tan^{-1}\left(\frac{1}{\mu}\right)$
*(NEET 2018)*

**48.** Two polaroids $P_1$ and $P_2$ are placed with their axis perpendicular to each other. Unpolarised light $I_0$ is incident on $P_1$. A third polaroid $P_3$ is kept in between $P_1$ and $P_2$ such that its axis makes an angle 45° with that of $P_1$. The intensity of transmitted light through $P_2$ is
(a) $\frac{I_0}{4}$ (b) $\frac{I_0}{8}$ (c) $\frac{I_0}{16}$ (d) $\frac{I_0}{2}$
*(NEET 2017)*

**49.** Which of the phenomenon is not common to sound and light waves ?
(a) Interference (b) Diffraction
(c) Coherence (d) Polarisation *(1988)*

## ANSWER KEY

| | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **1.** | (d) | **2.** | (b) | **3.** | (d) | **4.** | (d) | **5.** | (b) | **6.** | (a) | **7.** | (c) | **8.** | (c) | **9.** | (a) | **10.** | (b) |
| **11.** | (a) | **12.** | (c) | **13.** | (c) | **14.** | (c) | **15.** | (c) | **16.** | (b) | **17.** | (c) | **18.** | (b) | **19.** | (c) | **20.** | (c) |
| **21.** | (d) | **22.** | (b) | **23.** | (a) | **24.** | (d) | **25.** | (d) | **26.** | (a) | **27.** | (b) | **28.** | (d) | **29.** | (a) | **30.** | (c) |
| **31.** | (a) | **32.** | (c) | **33.** | (b) | **34.** | (d) | **35.** | (b) | **36.** | (c) | **37.** | (a) | **38.** | (d) | **39.** | (a) | **40.** | (c) |
| **41.** | (c) | **42.** | (c) | **43.** | (c) | **44.** | (d) | **45.** | (c) | **46.** | (c) | **47.** | (b) | **48.** | (b) | **49.** | (d) | | |

# Hints & Explanations

1. **(d) :** Huygen's construction of wavefront does not apply to origin of spectra which is explained by quantum theory.

2. **(b) :** $\mu = \dfrac{\text{velocity of light in vacuum } (c)}{\text{velocity of light in medium } (v)}$

$\therefore$ $v = \upsilon\lambda = 2 \times 10^{14} \times 5000 \times 10^{-10} = 10^8$ m/s

$\therefore$ $\mu = \dfrac{c}{v_{med}} = \dfrac{3\times10^8}{10^8} = 3$

3. **(d) :** Frequency = $n$; Wavelength = $\lambda$; Velocity of light in air = $v$ and refractive index of glass slab = $\mu$
Frequency of light remains the same, when it changes the medium. Refractive index is the ratio of wavelengths in vacuum and in the given medium. Similarly refractive index is also the ratio of velocities in vacuum and in the given medium.

4. **(d) :** Refractive index of water ($\mu_2$) = 1.33.

$$\frac{v_2}{v_1} = \frac{\mu_1}{\mu_2} = \frac{1}{1.33}$$

Therefore $v_2 = \dfrac{v_1}{1.33} = \dfrac{3\times10^8}{1.33} = 2.25\times10^8$ m/s

5. **(b) :** $\text{Time} = \dfrac{\text{distance}}{\text{velocity}} = \dfrac{t}{v} = \dfrac{t}{c/\mu} = \dfrac{\mu t}{c}$

6. **(a) :** Wavelength ($\lambda$) = 5000 Å and velocity ($v$) = $1.5 \times 10^4$ m/s
Wavelength of the approaching star,

$$\lambda' = = \lambda\frac{c-v}{c}$$

or $\dfrac{\lambda'}{\lambda} = 1 - \dfrac{v}{c}$ or, $\dfrac{v}{c} = 1 - \dfrac{\lambda'}{\lambda} = \dfrac{\lambda - \lambda'}{\lambda} = \dfrac{\Delta\lambda}{\lambda}$

Therefore $\Delta\lambda = \lambda \times \dfrac{v}{c} = 5000\text{Å} \times \dfrac{1.5\times10^6}{3\times10^8} = 25\text{Å}$

(here $\Delta\lambda$ is the change in the wavelength)

7. **(c) :** $v_g = \dfrac{c}{\mu} = \dfrac{3\times10^8}{\frac{3}{2}} = 2\times10^8$ m/s

$$t = \frac{x}{v_g} = \frac{4\times10^{-3}}{2\times10^8} = 2\times10^{-11}\text{ s}$$

8. **(c) :** $\lambda'$ of refracted light is smaller, because $\lambda' = \dfrac{\lambda}{\mu}$

9. **(a) :** $\lambda_g = \dfrac{\lambda_a}{\mu} = \dfrac{5460}{1.5} = 3640$ Å

10. **(b) :** Here, $\dfrac{I_1}{I_2} = n$

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

$$\frac{I_{max}-I_{min}}{I_{max}+I_{min}} = \frac{\frac{I_{max}}{I_{min}}-1}{\frac{I_{max}}{I_{min}}+1}$$

$$= \frac{\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)^2-1}{\left(\frac{\sqrt{n}+1}{\sqrt{n}-1}\right)^2+1} = \frac{(\sqrt{n}+1)^2-(\sqrt{n}-1)^2}{(\sqrt{n}+1)^2+(\sqrt{n}-1)^2} = \frac{4\sqrt{n}}{2(n+1)} = \frac{2\sqrt{n}}{n+1}$$

11. **(a) :** $\dfrac{I_1}{I_2} = \dfrac{a^2}{b^2} = \dfrac{4}{1}$ $\therefore$ $\dfrac{a}{b} = \dfrac{2}{1}$

12. **(c) :** Interference is a wave phenomenon shown by both the light waves and sound waves.

13. **(c) :** Fringe width, $\beta = \dfrac{D\lambda}{d}$

$d$ becomes half $\Rightarrow$ $d' = d/2$
$D$ doubles, so $\Rightarrow$ $D' = 2D$

New fringe width, $\beta' = \dfrac{2D\lambda}{\left(\frac{d}{2}\right)} = 4\beta$

14. **(c) :** Angular width for first minima in Young's double slit experiment, $\theta = \dfrac{\lambda}{a}$
For given value of $a$, $\theta \propto \lambda$

$$\frac{\theta}{\theta_w} = \frac{\lambda}{\lambda_w} = \frac{\lambda}{\frac{\lambda}{\mu}} = \mu \Rightarrow \theta_w = \frac{\theta}{\mu} = \frac{0.2°}{\frac{4}{3}} = 0.15°$$

15. **(c) :** Given, there is no initial phase difference.
$\therefore$ Initial phase = $\delta$ = 0

Again, phase difference $= \dfrac{2\pi}{\lambda} \times$ path difference

$$\Rightarrow \delta' = \frac{2\pi}{\lambda}\times\Delta x \Rightarrow \Delta x = \frac{\lambda}{2\pi}\times\delta'$$

Now, for the fifth minima we will consider $n = 4$ as initial phase difference is zero.
$\therefore$ For fifth minimum, $\delta' = (8 + 1)\pi = 9\pi$

$\therefore$ Path difference, $\Delta x = \dfrac{\lambda}{2\pi}\times 9\pi = \dfrac{9\lambda}{2}$

16. **(b) :** Angular width $= \dfrac{\lambda}{d}$

$0.20° = \dfrac{\lambda}{2\text{ mm}}$ and $0.21° = \dfrac{\lambda}{d}$

On dividing we get, $\frac{0.20}{0.21} = \frac{d}{2\,\text{mm}}$

$\therefore \quad d = 1.9$ mm

**17. (c) :** Position of 8th bright fringe in medium,

$$x = \frac{8\lambda_m D}{d}$$

Position of 5th dark fringe in air,

$$x' = \frac{\left(5 - \frac{1}{2}\right)\lambda_{air} D}{d} = \frac{4.5\,\lambda_{air} D}{d}$$

Given $x = x' \Rightarrow \frac{8\lambda_m D}{d} = \frac{4.5\lambda_{air} D}{d}$

$$\mu_m = \frac{\lambda_{air}}{\lambda_m} = \frac{8}{4.5} = 1.78$$

**18. (b) :** Here, $d = 5\lambda, D = 10d, y = \frac{d}{2}$

Resultant Intensity at $y = \frac{d}{2}, I_y = ?$

The path difference between two waves at $y = \frac{d}{2}$

$$\Delta x = d\tan\theta = d \times \frac{y}{D} = \frac{d \times \frac{d}{2}}{10d} = \frac{d}{20} = \frac{5\lambda}{20} = \frac{\lambda}{4}$$

Corresponding phase difference, $\phi = \frac{2\pi}{\lambda}\Delta x = \frac{\pi}{2}$

Now, maximum intensity in Young's double slit experiment,

$I_{max} = I_1 + I_2 + 2I_1I_2$ or $I_0 = 4I$ $\quad (\because \; I_1 = I_2 = I)$

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

Required intensity,

$$I_y = I_1 + I_2 + 2I_1I_2\cos\frac{\pi}{2} = 2I = \frac{I_0}{2}$$

**19. (c) :** As, intensity $I \propto$ width of slit $W$

Also, intensity $I \propto$ square of amplitude $A$

$$\therefore \quad \frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{A_1^2}{A_2^2}$$

But $\frac{W_1}{W_2} = \frac{1}{25}$ (given)

$$\therefore \quad \frac{A_1^2}{A_2^2} = \frac{1}{25} \quad \text{or} \quad \frac{A_1}{A_2} = \sqrt{\frac{1}{25}} = \frac{1}{5}$$

$$\therefore \quad \frac{I_{max}}{I_{min}} = \frac{(A_1 + A_2)^2}{(A_1 - A_2)^2} = \frac{\left(\frac{A_1}{A_2} + 1\right)^2}{\left(\frac{A_1}{A_2} - 1\right)^2}$$

$$= \frac{\left(\frac{1}{5} + 1\right)^2}{\left(\frac{1}{5} - 1\right)^2} = \frac{\left(\frac{6}{5}\right)^2}{\left(-\frac{4}{5}\right)^2} = \frac{36}{16} = \frac{9}{4}$$

**20. (c) :** Intensity at any point on the screen is

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

where $I_0$ is the intensity of either wave and $\phi$ is the phase difference between two waves.

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

When path difference is $\lambda$, then

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

$$\therefore \quad I = 4I_0\cos^2\left(\frac{2\pi}{2}\right) = 4I_0\cos^2(\pi) = 4I_0 = K \qquad \text{...(i)}$$

When path difference is $\frac{\lambda}{4}$, then

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

$$\therefore \quad I = 4I_0\cos^2\left(\frac{\pi}{4}\right) = 2I_0 = \frac{K}{2} \qquad \text{[Using (i)]}$$

**21. (d) :** Let $n_1$ bright fringe of $\lambda_1$ coincides with $n_2$ bright fringe of $\lambda_2$. Then

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

$$\frac{n_1}{n_2} = \frac{\lambda_2}{\lambda_1} = \frac{10000}{12000} = \frac{5}{6}$$

Let $x$ be given distance.

$$\therefore \quad x = \frac{n_1\lambda_1 D}{d}$$

Here, $n_1 = 5$, $D = 2$ m, $d = 2$ mm $= 2 \times 10^{-3}$ m

$\lambda_1 = 12000$ Å $= 12000 \times 10^{-10}$ m $= 12 \times 10^{-7}$ m

$$x = \frac{5 \times 12 \times 10^{-7}\,\text{m} \times 2\,\text{m}}{2 \times 10^{-3}\,\text{m}} = 6 \times 10^{-3}\,\text{m} = 6\,\text{mm}$$

**22. (b) :** Fringe width, $\beta = \frac{\lambda D}{d}$

where $D$ is the distance between slits and screen and $d$ is the distance between the slits.

When $D$ is doubled and $d$ is reduced to half, then fringe width becomes

$$\beta' = \frac{\lambda(2D)}{(d/2)} = \frac{4\lambda D}{d} = 4\beta$$

**23. (a)**

**24. (d) :** Separations between the slits

$d_1 = 16$ cm and $d_2 = 9$ cm

Actual distance of separation

$$d = \sqrt{d_1 d_2} = \sqrt{16 \times 9} = 12\ \text{cm}$$

**25. (d) :** In vacuum, $\lambda$ increases very slightly compared to that in air. As $\beta \propto \lambda$, therefore, width of interference fringe increases slightly.

**26. (a) :** As $\beta = \frac{\lambda D}{d}$ and $\lambda_b < \lambda_y$,

$\therefore$ Fringe width $\beta$ will decrease.

**27. (b) :** $x = (n)\lambda\frac{D}{d} = 3 \times 5000 \times 10^{-10} \times \frac{2}{0.2 \times 10^{-3}}$

$= 1.5 \times 10^{-2}$ m = 1.5 cm

**28. (d) :** For dark fringe, $x = (2n-1)\frac{\lambda D}{2d}$

$$\lambda = \frac{2xd}{(2n-1)D} = \frac{2 \times 10^{-3} \times 0.9 \times 10^{-3}}{(2 \times 2 - 1) \times 1}$$

$\lambda = 0.6 \times 10^{-6}$ m $= 6 \times 10^{-5}$ cm

**29. (a) :** $\beta' = \frac{\beta}{\mu} = \frac{0.4}{4/3} = 0.3$ mm

**30. (c) :** Distance of $n^{th}$ maxima $x = n\lambda\frac{D}{d} \propto \lambda$

As $\lambda_b < \lambda_g$

$\therefore$ $x$(blue) < $x$(green).

**31. (a) :** Given $\lambda$ = 600 nm $= 600 \times 10^{-9}$ m and $D$ = 2 m

$\therefore$ Limit of resolution $= \frac{1.22\lambda}{D} = \frac{1.22 \times 600 \times 10^{-9}}{2}$

$= 366 \times 10^{-9} = 3.66 \times 10^{-7}$ rad

**32. (c) :** For telescope, angular magnification $= \frac{f_0}{f_e}$

Angular resolution $= \frac{D}{1.22\,\lambda}$ should be large.

So, objective lens should have large focal length ($f_0$) and large diameter $D$ for large angular magnification and high angular resolution.

**33. (b) :** The resolving power of an optical microscope,

$$\text{RP} = \frac{2\mu \sin\theta}{\lambda}$$

For wavelength $\lambda_1$ = 4000 Å, resolving power will be

$$\text{RP}_1 = \frac{2\mu \sin\theta}{4000} \quad \text{...(i)}$$

For wavelength $\lambda_2$ = 6000 Å, resolving power will be

$$\text{RP}_2 = \frac{2\mu \sin\theta}{6000} \quad \text{...(ii)}$$

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

$$\frac{\text{RP}_1}{\text{RP}_2} = \frac{6000}{4000} = \frac{3}{2}$$

**34. (d) :** Here, $a$ = 0.02 cm $= 2 \times 10^{-4}$ m

$\lambda = 5 \times 10^{-5}$ cm $= 5 \times 10^{-7}$ m

$D$ = 60 cm = 0.6 m

Position of first minima on the diffraction pattern,

$$y = \frac{D\lambda}{a} = \frac{0.6 \times 5 \times 10^{-7}}{2 \times 10^{-4}} = 15 \times 10^{-4} \text{ m} = 0.15 \text{ cm}$$

**35. (b) :** For first minimum, the path difference between extreme waves,

$a\sin\theta = \lambda$

Here $\theta = 30° \Rightarrow \sin\theta = \frac{1}{2}$

$\therefore$ $a = 2\lambda$ ...(i)

For first secondary maximum, the path difference between extreme waves

$a\sin\theta' = \frac{3}{2}\lambda$ or $(2\lambda)\sin\theta' = \frac{3}{2}\lambda$ [Using eqn (i)]

or $\sin\theta' = \frac{3}{4}$ $\therefore$ $\theta' = \sin^{-1}\left(\frac{3}{4}\right)$

**36. (c) :** For double slit experiment,

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

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

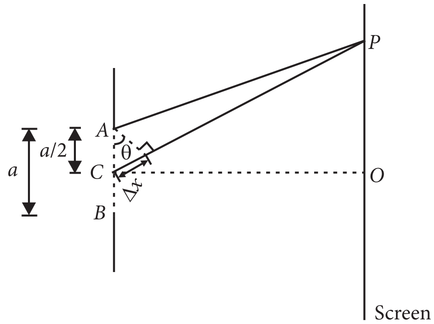
Width of central maxima in a single slit $= \frac{2\lambda D}{a}$

As per question, width of central maxima of single slit pattern = width of 10 maxima of double slit pattern

$$\frac{2\lambda D}{a} = 10\left(\frac{\lambda D}{d}\right) \text{ or } a = \frac{2d}{10} = \frac{2 \times 10^{-3}}{10}$$

$= 0.2 \times 10^{-3}$ m = 0.2 mm

**37. (a) :** The situation is shown in the figure.




In figure $A$ and $B$ represent the edges of the slit $AB$ of width $a$ and $C$ represents the midpoint of the slit.

For the first minimum at $P$,

$a\sin\theta = \lambda$ ...(i)

where $\lambda$ is the wavelength of light.

The path difference between the wavelets from $A$ to $C$ is

$$\Delta x = \frac{a}{2}\sin\theta = \frac{1}{2}(a\sin\theta) = \frac{\lambda}{2} \quad \text{(using(i))}$$

The corresponding phase difference $\Delta\phi$ is

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

**38. (d) :** Here, $\lambda$ = 600 nm $= 600 \times 10^{-9}$ m

$a$ = 1 mm $= 10^{-3}$ m, $D$ = 2 m

Distance between the first dark fringes on either side of the central bright fringe is also the width of central maximum.

Width of central maximum $= \frac{2\lambda D}{a}$

$$= \frac{2\times 600\times 10^{-9}\ \text{m}\times 2\ \text{m}}{10^{-3}\ \text{m}}$$

$= 24 \times 10^{-4}$ m $= 2.4 \times 10^{-3}$ m $= 2.4$ mm

**39. (a)**

**40. (c) :** For the second minimum,
Path difference = $2\lambda$
Therefore, corresponding value of phase difference is

$$\Delta\phi = \frac{2\pi}{\lambda}\times \text{Path difference} = \frac{2\pi}{\lambda}\times 2\lambda = 4\pi$$

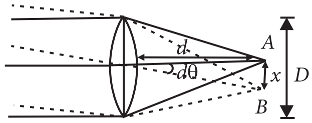
**41. (c) :** R.P. = $1/\Delta\theta$

The angular resolution, $\Delta\theta = \frac{1.22\lambda}{D}$

$$= \frac{1.22\times 5000\times 10^{-8}}{0.1} = 6.1\times 10^{-4} \simeq 10^{-4}\ \text{rad}$$

**42. (c) :** Resolution of telescope

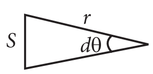
$$d\theta = 1.22\frac{\lambda}{D} = 1.22\times\frac{5000\times 10^{-8}}{10}$$




$$x = d\theta\times d = \frac{1.22\times 5000\times 10^{-8}\times 10^{5}}{10} = 6.1\times 10^{-1}\ \text{cm} \simeq 5\ \text{mm}$$

**43. (c) :** Given $d$ = diameter of lens = 2 mm = $2 \times 10^{-1}$ cm,
$\lambda = 5000$ Å $= 5000 \times 10^{-8}$ cm
Resolving power of eye lens

$$= \frac{d}{\lambda} = \frac{2\times 10^{-1}}{5000\times 10^{-8}} = \frac{1}{d\theta}$$




Let $S$ be the minimum distance between two points so that it may be resolved.

$\therefore$ $S = r\,d\theta$. Here $r = 50$ m $= 5000$ cm

$$\therefore\ S = 5000\times\frac{5000\times 10^{-8}}{2\times 10^{-1}} = 1.25\ \text{cm}$$

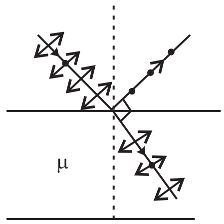
**44. (d)**

**45. (c) :** For first minimum, $a\sin\theta = n\lambda = 1\lambda$

$$\sin\theta = \frac{\lambda}{a} = \frac{5000\times 10^{-10}}{0.001\times 10^{-3}} = 0.5 \quad \text{or} \quad \theta = 30°$$

**46. (c) :** We know, $\mu = \tan i_b$
As $1 < \mu < \infty$
$\therefore$ $1 < \tan i_b < \infty$
$\tan(45°) < \tan i_b < \tan(90°)$
or $45° < i_b < 90°$.

**47. (b) :** When reflected light and refracted light are perpendicular, reflected light is polarised with electric field vector perpendicular to the plane of incidence.




Also, $\tan i = \mu$ (Brewster angle)

**48. (b) :** The intensity of transmitted light through $P_1$,

$$I_1 = \frac{I_0}{2}$$

The intensity of transmitted light through $P_3$,

$$I_2 = I_1\cos^2 45° = \frac{I_0}{2}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I_0}{2}\cdot\frac{1}{2} = \frac{I_0}{4}$$

Angle between polaroids $P_3$ and $P_2$
$= (90° - 45°) = 45°$

$\therefore$ Intensity of transmitted light through $P_2$,

$$I_3 = I_2\cos^2 45° = \frac{I_0}{4}\left(\frac{1}{\sqrt{2}}\right)^2 = \frac{I_0}{8}$$

**49. (d) :** Sound waves can not be polarised as they are longitudinal. Light waves can be polarised as they are transverse.

❖ ❖ ❖