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Wave Optics

TOPIC 1
Huygen's Principle and and Interefernce of Light

01 Two coherent sources of light interfere and produce fringe pattern on a screen. For central maximum, the phase difference between the two waves will be **[NEET (Oct.) 2020]**

(a) zero (b) π
(c) $3\pi/2$ (d) $\pi/2$

Ans. *(a)*

For central maximum, path difference is zero for both coherent sources in interference.

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

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

02 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 **[NEET (Sep.) 2020]**

(a) half (b) four times
(c) one-fourth (d) double

Ans. *(b)*

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

$$\therefore \quad \frac{\beta_2}{\beta_1} = \frac{\frac{\lambda_2 D_2}{d_2}}{\frac{\lambda_1 D_1}{d_1}}$$

$[\text{As } \lambda_1 = \lambda_2,\ D_2 = 2D_1 \text{ and } d_2 = \frac{d_1}{2}]$

$$\therefore \quad \frac{\beta_2}{\beta_1} = \frac{2D_1}{\left(\frac{d_1}{2}\right)} \times \frac{d_1}{D_1} = 4$$

$$\Rightarrow \quad \beta_2 = 4\beta_1$$

i.e., fringe width becomes four times. Hence, correct option is (b).

03 In a Young's 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. **[NEET (Odisha) 2020]**

(a) $5\frac{\lambda}{2}$ (b) $10\frac{\lambda}{2}$
(c) $9\frac{\lambda}{2}$ (d) $11\frac{\lambda}{2}$

Ans. *(c)*

In a *YDSE*, the path difference for *n*th minima is given by

$$\Delta y = (2n-1)\frac{\lambda}{2}$$

For 5th minima, $n = 5$

$$\therefore \quad \Delta y = [2(5)-1]\frac{\lambda}{2} = \frac{9\lambda}{2}$$

04 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 0.2º. What will be the angular width of the first minima, if the entire experimental apparatus is immersed in water? ($\mu_{water} = 4/3$) **[NEET (National) 2019]**

(a) 0.15º (b) 0.051°
(c) 0.1º (d) 0.266º

Ans. *(a)*

The angular width in YDSE is given by

$$\theta = \frac{\beta}{D}$$

where, β is the separation between two fringes. D is the distance between the planed the slits and screen. If YDSE apparatus is immersed in a liquid of refractive index μ, then the wavelength of light and hence the angular width decreases μ times.

i.e.

and $$\theta' = \frac{\beta}{\mu D} = \frac{\theta}{\mu}$$

Here, μ (for water) $= 4/3$ and

$$\theta = 0.2°$$

$$\Rightarrow \quad \theta' = \frac{0.2}{4/3} = 0.15°$$

05 In Young's double slit experiment, the separation *d* between the slits is 2 mm, the wavelength λ 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 λ and *D*) the separation between the slits needs to be changed to **[NEET 2018]**

(a) 2.1 mm (b) 1.9 mm
(c) 1.8 mm (d) 1.7 mm

Ans. *(b)*

In a YDSE, angular width of a fringe is given as

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

where, λ is the wavelength of the light source and *d* is the distance between the two slits.

$\Rightarrow \qquad \theta \propto \frac{1}{d}$

or $\qquad \frac{\theta_1}{\theta_2} = \frac{d_2}{d_1}$ ...(i)

Here, $\theta_1 = 0.20°$, $\theta_2 = 0.21°$,
$d_1 = 2\,\text{mm}$

Substituting the given values in Eq. (i), we get

$$\frac{0.20°}{0.21°} = \frac{d_2}{2\text{ mm}}$$

$$\Rightarrow \quad d_2 = 2 \times \frac{0.20}{0.21} = \frac{0.40}{0.21}$$

$$\therefore \quad = 1.90\text{ mm}$$

06 Young's double slit experiment is first performed in air and then in a medium other than air. It is found that 8th bright fringe in the medium lies where 5th dark fringe lies in air. The refractive index of the medium is nearly **[NEET 2017]**

(a) 1.25 (b) 1.59
(c) 1.69 (d) 1.78

Ans. ***(d)***

According to question,

5th dark fringe in air = 8 bright fringe in the medium

$$(2 \times 5 - 1)\frac{\lambda D}{2d} = 8\frac{\lambda D}{\mu d} \Rightarrow 9\frac{\lambda D}{2d} = 8\frac{\lambda D}{\mu d}$$

$$\Rightarrow \quad \frac{9}{2} = \frac{8}{\mu} \Rightarrow \mu = \frac{8 \times 2}{9}$$

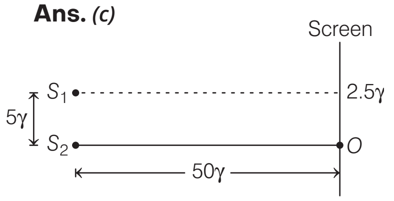
$\therefore$ Refractive index of the medium,

$$\mu = \frac{16}{9} = 1.7777 \approx 1.78$$

07 The intensity at the maximum in a Young's double slit experiment is I_0. Distance between two slits is $d = 5\lambda$, where λ is the wavelength of light used in the experiment. What will be the intensity infront of one of the slits on the screen placed at a distance $D = 10\,d$? **[NEET 2016]**

(a) $\frac{I_0}{4}$ (b) $\frac{3}{4}I_0$
(c) $\frac{I_0}{2}$ (d) I_0

Ans. ***(c)***



In the above figure, S_1 and S_2 are the two different slits.

Given, distance between slits S_1 and S_2,

$d = 5\lambda$

distance between screen and slits,

$$D = 10d = 50\lambda$$

Here, λ is the wavelength of light used in the experiment.

According to question, the intensity at maximum in this Young's double slit experiment is I_0.

$$\Rightarrow \quad I_{\max} = I_0$$

$\because$ Path difference

$$= \frac{dY_n}{D} = \frac{d \times \frac{d}{2}}{10d} = \frac{d}{20} = \frac{\lambda}{4}$$

$\{\because d = 5\lambda\}$

A path difference of λ corresponds to phase difference 2π

So, for path difference $\lambda/4$, phase difference

$$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{4} = \pi/2 = 90°$$

As we know, $I = I_0 \cos^2 \frac{\phi}{2}$

$$\Rightarrow \quad I = I_0 \cos^2 \frac{90°}{2}$$

$$\Rightarrow \quad I = I_0 \times \left(\frac{1}{\sqrt{2}}\right)^2 \Rightarrow I = \frac{I_0}{2}$$

08 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 **[NEET 2016]**

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

Ans. ***(b)***

It is given that, $\frac{I_2}{I_1} = n \Rightarrow I_2 = nI_1$

$\therefore$ Ratio of intensities is given by

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

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

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

09 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? **[CBSE AIPMT 2015]**

(a) 0.2 mm (b) 0.1 mm
(c) 0.5 mm (d) 0.02 mm

Ans. ***(a)***

Given $d = 1\text{mm} = 1 \times 10^{-3}\text{m}$

$$D = 1\text{m}, \lambda = 500\text{ nm} = 5 \times 10^{-7}\text{ m}$$

As width of central maxima = width of 10 maxima

$$\therefore \quad \frac{2D\lambda}{a} = 10\left(\frac{\lambda D}{d}\right)$$

$$\Rightarrow \quad a = \frac{d}{5} = \frac{10^{-3}}{5} = 0.2 \times 10^{-3}\text{m}$$

$$a = 0.2\text{ mm}$$

10 Two slits in Youngs 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 **[CBSE AIPMT 2015]**

(a) $\frac{9}{4}$ (b) $\frac{121}{49}$
(c) $\frac{49}{121}$ (d) $\frac{4}{9}$

Ans. ***(a)***

Given, YDSE experiment, having two slits of width are in the ratio of 1 : 25.

So, ratio of intensity,

$$\frac{I_1}{I_2} = \frac{W_1}{W_2} = \frac{1}{25} \Rightarrow \frac{I_2}{I_1} = \frac{25}{1}$$

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

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

Thus, $\frac{I_{\max}}{I_{\min}} = \frac{9}{4}$

11 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 **[CBSE AIPMT 2014]**

(a) K (b) $K/4$
(c) $K/2$ (d) zero

Ans. *(c)*

For net intensity

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

For the first case, $K = 4I_0 \cos^2 [\pi]$ $\because$ $\left(\phi = \frac{2\pi}{\lambda} \times \lambda\right)$

$$K = 4I_0 \quad \text{...(i)}$$

For the second case,

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

$$\because \quad \left(\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{4}\right)$$

$$K' = 2I_0 \quad \text{...(ii)}$$

Comparing Eqs. (i) and (ii), we get

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

12 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? **[NEET 2013]**

(a) 8 mm (b) 6 mm
(c) 4 mm (d) 3 mm

Ans. *(b)*

Given, $\lambda_1 = 12000$ Å and $\lambda_2 = 10000$ Å, $D = 2$ m and $d = 2$ mm $= 2 \times 10^{-3}$ m.

Fringe-width of first wavelength,

$$\beta_1 = \frac{\lambda_1 D}{d} = \frac{12000 \times 10^{-10} \times 2}{2 \times 10^{-3}} = 1.2 \text{ mm}$$

Fringe-width of second waveleng th,

$$\beta = \frac{\lambda_2 D}{d} = \frac{10000 \times 10^{-10} \times 2}{2 \times 10^{-3}} = 1\text{mm}$$

At 6 mm distance from central bright fringe, 5^{th} fringe of first wavelength coincide with 6^{th} fringe of second wavelength.

13 Colours of thin soap bubbles are due to **[CBSE AIPMT 1999]**

(a) refraction
(b) dispersion
(c) interference
(d) diffraction

Ans. *(c)*

When white light is incident on a soap bubble it is partly reflected from upper surface and partly reflected from lower surface. These two reflected beams superpose to cause interference. The colours which satisfy the condition of maxima are visible in reflected light. So, colours of soap bubbles are caused due to interference.

TOPIC 2
Diffraction and Polarisation of Light

14 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 **[NEET (Sep.) 2020]**

(a) 1.83×10^{-7} rad (b) 7.32×10^{-7} rad
(c) 6.00×10^{-7} rad (d) 3.66×10^{-7} rad

Ans. *(d)*

Given, light of wavelength, $\lambda = 600$ nm $= 600 \times 10^{-9}$ m

Diameter, $d = 2$ m

As, limit of resolution of telescope,

$$d\theta = \frac{1.22\lambda}{d} = \frac{1.22 \times 600 \times 10^{-9}}{2} = 3.66 \times 10^{-7} \text{ rad}$$

Hence, correct option is (d).

15 The Brewster's angle i_b for an interface should be **[NEET (Sep.) 2020]**

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

Ans. *(b)*

The Brewster's angle i_b for an interface should lies between 45° to 90°, i.e. $45° < i_b < 90°$.

Hence, correct option is (b).

16 Angular width of the central maxima in the Fraunhoffer diffraction for $\lambda = 6000$ Å is θ_0. When the same slit is illuminated by another monochromatic light, the angular width decreases by 30%. The wavelength of this light is **[NEET (Odisha) 2019]**

(a) 1800 Å (b) 4200 Å
(c) 6000 Å (d) 420 Å

Ans. *(b)*

The angular width of central maxima is given by

$$2\theta = \frac{2\lambda}{a} \quad \text{...(i)}$$

where, λ = wavelength of light used
a = width of the slit

For $\lambda_1 = 6000$ Å, $2\theta = \theta_0$ (given)

For another light of wavelength λ_2 (says), the angular width decreases by 30% so,

$$2\theta = \left(\frac{100-30}{100}\right)\theta_0 = \frac{70}{100}\theta_0 = 0.7\theta_0$$

As slit width is constant, so using Eq. (i) for these values, we get

$$\frac{\theta_0}{0.7\theta_0} = \frac{\lambda_1}{\lambda_2}$$

$$\Rightarrow \quad \lambda_2 = \lambda_1 \times 0.7 = 6000 \times 0.7 = 4200 \text{ Å}$$

17 An astronomical refracting telescope will have large angular magnification and high angular resolution, when it has an objective lens of **[NEET 2018]**

(a) large focal length and large diameter
(b) large focal length and small diameter
(c) small focal length and large diameter
(d) small focal length and small diameter

Ans. *(c)*

Angular magnification of an astronomical refracting telescope is given as

$$M = \frac{f_0}{f_e}$$

where, f_0 and f_e are the focal length of objective and eye-piece, respectively.

From the given relation, it is clear that for large magnification either f_0 has to be large or f_e has to be small.

Angular resolution of an astronomical refracting telescope is given as

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

where, a is the diameter of the objective.

Thus, to have large resolution, the diameter of the objective should be large.

Hence, from the above objective lens should have large focal length (f_0) and large diameter (a).

18 Unpolarised light is incident from air on a plane surface of a material of refractive index 'μ'. 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? **[NEET 2018]**

(a) $i = \sin^{-1}\left(\frac{1}{\mu}\right)$

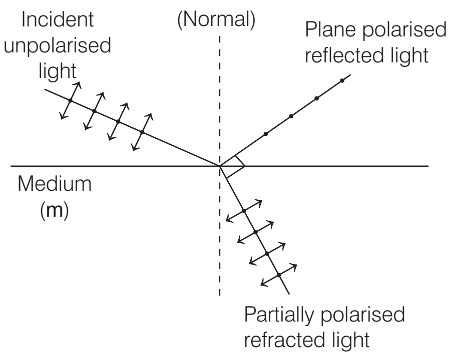
(b) Reflected light is polarised with its electric vector perpendicular to the plane of incidence

(c) Reflected light is polarised with its electric vector parallel to the plane of incidence

(d) $i = \tan^{-1}\left(\frac{1}{\mu}\right)$

Ans. *(b)*

The figure shown below represents the course of path an unpolarised light follows when it is incident from air on plane surface of material of refractive index μ.



When the beam of unpolarised light is reflected from a medium (refractive index $= \mu$) and if reflected and refracted light are perpendicular to each other. Then, the reflected light is completely plane polarised at a certain angle of incidence. This means, the reflected light has electric vector perpendicular to incidence plane.

19 The ratio of resolving powers of an optical microscope for two wavelengths $\lambda_1 = 4000\,\text{Å}$ and $\lambda_2 = 6000\,\text{Å}$ is **[NEET 2017]**

(a) 8 : 27 (b) 9 : 4
(c) 3 : 2 (d) 16 : 81

Ans. *(c)*

As, resolving power of a microscope,

$$(\text{RP}) \propto \frac{1}{\lambda_{(\text{wavelength})}}$$

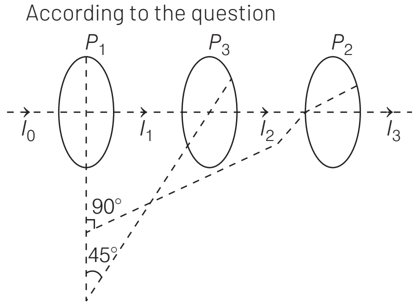
$$\therefore \quad \frac{\text{RP}_1}{\text{RP}_2} = \frac{\lambda_2}{\lambda_1} = \frac{6000}{4000} = \frac{3}{2}$$

20 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 **[NEET 2017]**

(a) $\frac{I_0}{2}$ (b) $\frac{I_0}{4}$
(c) $\frac{I_0}{8}$ (d) $\frac{I_0}{16}$

Ans. *(c)*

According to the question



From the above diagram, intensity transmitted through P_3

$$I_2 = \frac{I_0}{2}\cos^2 45° \Rightarrow I_2 = \frac{I_0}{2} \times \left(\frac{1}{\sqrt{2}}\right)^2$$

$$\Rightarrow \quad I_2 = \frac{I_0}{4}$$

Similarly, intensity transmitted through P_2,

$$I_3 = \frac{I_0}{4}\cos^2 45°$$

$$\Rightarrow \quad I_3 = \frac{I_0}{4} \times \left(\frac{1}{\sqrt{2}}\right)^2$$

$$\Rightarrow \quad I_3 = \frac{I_0}{4} \times \frac{1}{2} \Rightarrow I_3 = \frac{I_0}{8}$$

21 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 **[NEET 2016]**

(a) $\sin^{-1}\left(\frac{2}{3}\right)$ (b) $\sin^{-1}\left(\frac{1}{2}\right)$
(c) $\sin^{-1}\left(\frac{3}{4}\right)$ (d) $\sin^{-1}\left(\frac{1}{4}\right)$

Ans. *(c)*

As the first minimum is observed at an angle of 30° in a diffraction pattern due to a single slit of width a.

i.e. $n = 1$, $\theta = 30°$

$\because$ According to Bragg's law of diffraction,

$$a \sin\theta = n\lambda \Rightarrow a \sin 30° = (1)\,\lambda \;(n = 1)$$

$$\Rightarrow \quad a = 2\lambda \quad \text{...(i)}$$

$$\left\{\because \sin 30° = \frac{1}{2}\right\}$$

For Ist secondary maxima

$$\Rightarrow a \sin\theta_1 = \frac{3\lambda}{2} \Rightarrow \sin\theta_1 = \frac{3\lambda}{2a} \quad \text{...(ii)}$$

Substitute value of a from Eq. (i) to Eq. (ii), we get

$$\sin\theta_1 = \frac{3\lambda}{4\lambda} \Rightarrow \sin\theta_1 = \frac{3}{4}$$

$$\Rightarrow \quad \theta_1 = \sin^{-1}\left(\frac{3}{4}\right)$$

22 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 5×10^{-5} cm. The distance of the first dark band of the diffraction pattern from the centre of the screen is **[NEET 2016]**

(a) 0.10 cm (b) 0.25 cm
(c) 0.20 cm (d) 0.15 cm

Ans. *(d)*

Key Idea Ist minima is formed at a distance $Y = \frac{\lambda D}{a}$

For the distance of the first dark band of the diffraction pattern from the centre of the screen is given by positon of Ist minima.

i.e. $Y = \frac{\lambda D}{a}$

where, λ = wavelength of parallel beams

D = focal length

a = width of linear aperture.

$$\Rightarrow \quad Y = \frac{(5\times 10^{-5})(0.6)}{0.02\times 10^{-2}} \quad \text{(given)}$$

$$\Rightarrow \quad Y = 0.15 \text{ cm}$$

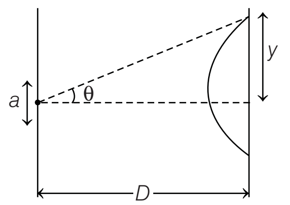
23 For a parallel beam of monochromatic light of wavelength 'λ' diffraction is produced by a single slit whose width 'a' is of the order of the wavelength of the light. If 'D' is the distance of the screen from the slit, the width of the central maxima will be **[CBSE AIPMT 2015]**

(a) $\frac{2D\lambda}{a}$ (b) $\frac{D\lambda}{a}$

(c) $\frac{Da}{\lambda}$ (d) $\frac{2Da}{\lambda}$

Ans. ***(a)***

For the condition of maxima



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

From the geometry, $\sin\theta = \theta = \frac{Y}{D}$ (for small angle)

So, $\frac{Y}{D} = \frac{\lambda}{a}$

$$\Rightarrow \quad Y = \frac{\lambda D}{a}$$

Hence, width of central maxima

$$= 2Y = \frac{2\lambda D}{a}$$

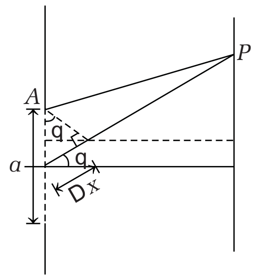
24 At the first minimum adjacent to the central maximum of a single slit diffraction pattern, the phase difference between the Huygen's wavelet from the edge of the slit and the wavelet from the midpoint of the slit is **[CBSE AIPMT 2015]**

(a) $\frac{\pi}{4}$ radian (b) $\frac{\pi}{2}$ radian

(c) π radian (d) $\frac{\pi}{8}$ radian

Ans. ***(c)***

For first minima at P, $a\sin\theta = n\lambda$



where, $N = 1 \Rightarrow a\sin\theta = \lambda$

So, phase difference,

$$\Delta\phi_1 = \frac{\Delta x_1}{\lambda}\times 2\pi = \frac{(a/2)\sin\theta}{\lambda}\times 2\pi$$

$$= -\frac{\lambda}{2\lambda}\times 2\pi = \pi \text{ rad}$$

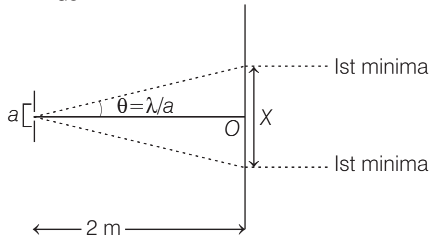
25 A beam of light of $\lambda = 600$ nm from a distant source falls on a single slit 1 mm wide and the resulting diffraction pattern is observed on a screen 2 m away. The distance between first dark fringes on either side of the central bright fringe is **[CBSE AIPMT 2014]**

(a) 1.2 cm (b) 1.2 mm

(c) 2.4 cm (d) 2.4 mm

Ans. ***(d)***

According to question diagram is shown as



$$\tan\theta = \frac{x/2}{2}$$

For small θ and when θ is counted in rad, $\tan\theta \approx \theta$

So, $\theta = \frac{x/2}{2} \Rightarrow \frac{\lambda}{a} = \frac{x}{4}$

$$\Rightarrow \quad x = \frac{4\lambda}{a} = \frac{4\times 600\times 10^{-9}}{10^{-3}}$$

$$= 24\times 10^{-4} \text{ m}$$

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

26 The angular resolution of a 10 cm diameter telescope at a wavelength of 5000 Å is of the order of **[CBSE AIPMT 2005]**

(a) 10^{6} rad (b) 10^{-2} rad

(c) 10^{-4} rad (d) 10^{-6} rad

Ans. ***(d)***

Angular resolution of telescope is given by

$$= \frac{1.22\,\lambda}{d} = \frac{1.22\times 5000\times 10^{-10}}{10\times 10^{-2}}$$

$$= 6.1\times 10^{-6} \approx 10^{-6} \text{ rad}$$