CH-11

Interference of Light.

The phenomenon of redistribution of energy in the resultant light wave formed by the superposition of two light waves having same amplitude and frequency (or wavelength) is called interference of light.

Types of interference:- (i) If the amplitude is maximum (hence, the intensity of light is maximum), then it is called constructive interference.

(ii) Destructive interference:- The interference in which the amplitude and intensity of resultant wave become zero is called destructive interference.

Q(1) Coherent sources:- Two source of light are called coherent if they emit light waves having same frequency or wavelength and amplitude and the two waves are in the same phase.

The two source of light are called incoherent if they are not in same phase. practically two independent

Teacher's Signature.....

Page:
Date: / /

source of light are incoherent.

S.Q(2) Conditions for constructive and destructive interference of light:-

(i) The condition for constructive interference is that, the path difference between two waves should be zero or integral multiple of wavelength 'λ'. Thus

$$x = n\lambda \; ; \; n = 0, 1, 2, \ldots .$$

(ii) The condition for destructive interference is that, the path difference between two waves must be odd multiple of $\frac{\lambda}{2}$, Thus

$$x = (2n+1)\cdot\frac{\lambda}{2} \; ; \; n = 0, 1, 2 \ldots$$

SQ(3) Why two independent sources of light (eg two head lights of a bus) not produced interference [2074]

Ans Two independent sources of light do not produce interference because they are incoherent and production of interference requires coherent sources.

SQ(4) Is there violation of law of conservation of energy? explain [2072, 2073 supply]

Ans No, there is only redistribution of energy in the interference of light. This is because the energy of dark fringe is shifted to the bright fringe and again the total energy remains the same.

SQ(5) In young's double slit experiment, how is the fringe width altered if the separation between two slits is doubled and the distance between slit and screen is halved? [HSEB-2068]

Page :
Date: / /

Ans New fringe width

$$\beta' = \frac{\lambda D'}{d'} \quad \left\{ \text{here, } d' = 2d, \; D' = \frac{D}{2} \right\}$$

thus $\beta' = \frac{\beta}{4}$ = one fourth of previous value.

Sq (6) Why have the co two coherent sources be very close to each other for good interference pattern? [2058]

Ans Fringe width of interference pattern is given by

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

thus, the slits seperation d being inversely proportional to fringe width, the two source must be very close.

Sq (7) Differences between interference and diffraction?

Ans

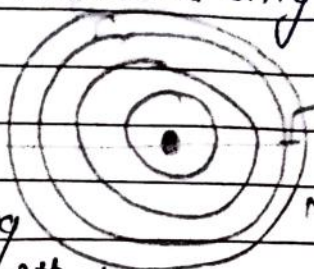
	Interference	Diffraction
(1)	It is the result of superpos-tion of light waves coming from two coherent sources.	(1) Diffraction is the result of superposition of two waves coming from diff-erent points of the same wave front.
(2)	Interference bands are equally spaced.	(2) Diffraction bands are not equally spaced.
(3)	points of minimum intensity are perfectly dark.	(3) Points of minimum intensity are not perfectly dark.
(4)	All bright bands are of uniform intensity.	(4) All bright bands are not of uniform intensity.
(5)	Bands are large in number	(5) Bands are few in number.

Teacher's Signature.....

$d = \lambda$

Page:
Date: / /

Newton's rings Experiment: (for numerical only)



$$d = \frac{D_{n+m}^2 - D_n^2}{4mR}$$

here, D_n = diameter of n^{th} dark ring
D_{n+m} = diameter of $(n+m)^{th}$ dark ring
R = radius of curvature of convex surface of plano convex lens.

Important

Numerical [2075 set B] Q-12

Given
In Newton's ring expt:
$D_{15} = 0.590\ cm$
$D_5 = 0.336\ cm$
$R = ?$
$\lambda = 5880\ A^\circ = 5880 \times 10^{-8}\ cm$
Here,
$D_{15} = D_5 + 10 = D_{n+m}$
where $n = 5$
$m = 10$
Now,

$$d = \frac{D_{n+m}^2 - D_n^2}{4mR}$$

$$\lambda = \frac{D_{15}^2 - D_5^2}{4 \times 10 \times R}$$

$$R = \frac{(0.590)^2 - (0.336)^2}{40 \times 5880 \times 10^{-8}}$$

$$= 100\ cm$$
$$= 1\ meter.$$

Imp.

Page :
Date: / /

Young's double slit experiment :-

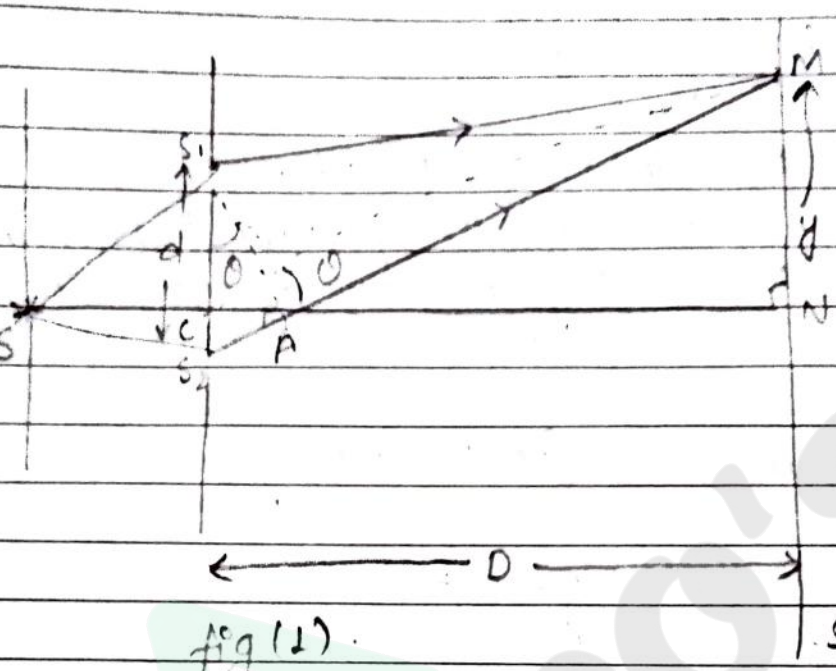


fig (1)

Fig (1) shows experimental arrangement of Young's two slit experiment. Slits S_1 and S_2 are equally spaced from monochromatic source of light S and act as coherent source. Due to constructive and destructive interference of light coming from S_1 and S_2 on screen alternate bright and dark fringes (or bands) are obtained on the screen.

At point M on screen the path difference between rays S_2M and S_1M will be

$$\text{Path difference} = S_2M - S_1M$$
$$= S_2A + AM - S_1M = \left[\because S_1M = AM\right]$$
$$S_2A \quad \text{---} (1)$$

In ΔS_1S_2A

$$\sin\theta = \frac{S_2A}{S_1S_2} = \frac{S_2A}{d} \quad \text{---} (2)$$

And in ΔMCN, $\tan\theta = \frac{MN}{CN} = \frac{y}{D}$ --(3)

Teacher's Signature.....

Page:
Date: / /

Since θ is very small

$\tan\theta \simeq \sin\theta \simeq \theta$, therefore equating (2) and (3) we get

$$\frac{S_2A}{d} = \frac{y}{D} \Rightarrow S_2A = \frac{yd}{D} \quad \text{-(4)}$$

Bright fringe width (α):

For the point M1 to be bright fringe, path difference must be integral multiple of wave length.

Thus,

$$S_2A = n\lambda = \frac{yd}{D} \; ; \; n = 0, 1, 2,$$

$$\boxed{\text{Or, } y_n = \frac{n \cdot D\lambda}{d}} \quad \text{(for bright fright or maxima)}$$

From eq (5) seperation between two nearest bright fringes will be

$$\alpha = (y_{n+2} - y_n) = \frac{\lambda D}{d}\left[n+1-n\right]$$

Thus, $\boxed{\alpha = \frac{\lambda D}{d}}$ -- (6)

Dark fringe width:- For point M to be dark, path difference must be odd multiple of $\frac{\lambda}{2}$. Thus

$$S_2A = \frac{yd}{D} = (2n+1)\cdot\frac{\lambda}{2} \quad \left[\text{where } n = 0, 1, 2\right]$$

$$\Rightarrow \frac{(2n+1)\lambda D}{2d} = y_{2n+1} \quad \text{--(7)}$$

From eqn (7), the distance between two nearest dark fringes will be

$$\beta = y_{(2n+1)+2} - y_{(2n+1)} = \frac{\lambda D}{2d}\left[2n+3-2n-1\right]$$

$$\boxed{\beta = \frac{\lambda D}{d}} \quad \text{...(8)}$$

Teacher's Signature.....

From equs (7) and (8) we see that the bright and dark fringes are of equal width.

Numericals.

(1) (2068 Q.12) Two slits space 0.45 mm apart are place 75 cm from a screen. What is the distance between the second and third lines of the inference pattern on the screen when slits are illuminated with monochromatic light of wave length 500 nm?

⇒ Given;

In two slit expt

$d = 0.45\text{mm} = 0.45 \times 10^{-3}$ m

$D = 0.75$ m

β = ? distance between second and third dark lines

$\lambda = 500\text{nm} = 500 \times 10^{-9}$ m.

Soln

$$\beta = \frac{\lambda D}{d} = \frac{500 \times 10^{-9} \times 0.75}{0.45 \times 10^{-3}}$$

= 8.3*10^4 m meter

(2) (2068 Q.12) In a young's slits experiment, the separation of fourth fringes is 2.5mm. when the wavelength used is 6.2×10^{-7} m. The distance from the slits to the screen is 0.80 m. calculate seperation of two slits?

Given

In two slit expt.

y_4 = separation of 4 bright fringes = 2.5 mm

$= 2.5 \times 10^{-3}$ m

$\lambda = 6.2 \times 10^{-7}$ m

$D = 0.8$ m

Teacher's Signature.....

Page:
Date: / /

d = ? slits separation.

Soln;

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

$$\therefore y_4 = \frac{4\lambda D}{d}$$

$$\therefore d = \frac{4\lambda D}{y_4} = \frac{4 \times 6.2 \times 10^{-7} \times 0.8}{2.5 \times 10^{-3}}$$

$$= 793.6 \times 10^{-4} \text{ m}.$$

13) 2067 (6.b) In a young's double slit experiment the separation between first and fifth bright fringes is 2.5 mm. When the wavelength of light used is 6.2×10^{-4} mm. The distance from the slits to the screen is 80 cm. Calculate the separation of two slits?

⇒ Here

Given,

In two slit expt separation between first and fifth bright fringe $= (y_5 - y_1) = 2.5 \times 10^{-3}$ m.

$D = 0.80$ m

$d = 6.2 \times 10^{-4}$ mm

$= 6.2 \times 10^{-7}$ m.

d = ? slit separation.

Soln

$$(y_5 - y_1) = \frac{5\lambda D}{d} = \frac{4\lambda D}{d}$$

$$\therefore d = \frac{4\lambda D}{(y_5 - y_1)}$$

$$= \frac{4 \times 6.2 \times 10^{-7} \times 0.8}{2.5 \times 10^{-3}}$$

$$= (8 \times 10^{-4}) \text{ meter.}$$

4) In young's expt the distance centre to tenth bright fringe on either side is 3.44 cm. Distance between slits and the screen is 2m. If $\lambda = 5.89 \times 10^{-7}$ m; determine slit separation and the angle made by the central bright fringe at the slit [2060]

Soln

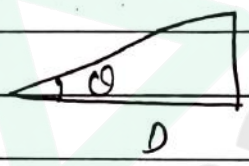
(i) $y_{10} = \frac{10\lambda D}{d}$

$\Rightarrow d = \frac{10\lambda D}{y_{10}} = \frac{10 \times 5.89 \times 10^{-7} \times 2}{3.44 \times 10^{-2}}$

$= (3.42 \times 10^{-4})$ meter.

ii) $\alpha \simeq \theta = \frac{\lambda}{d}$

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



$= \frac{\lambda}{d} = \frac{5.89 \times 10^{-7}}{3.42 \times 10^{-4}} = 1.72 \times 10^{-3}$ radian

(5) The separation between the consecutive dark fringes in a young's double slit experiment is 1 mm. The screen is placed at a distance of 2m from slits & 1.0 mm separation. What is the wavelength of light used in experiment?

Solⁿ ⇒ Given,

In two slit expt

β = fringe width of dark fringe = 1 mm

$= 1 \times 10^{-3}$ m

$D = 2$ meter

d = slits seperation = 1mm = 10^{-3} m

λ = ? wavelength

Soln

Teacher's Signature.....

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

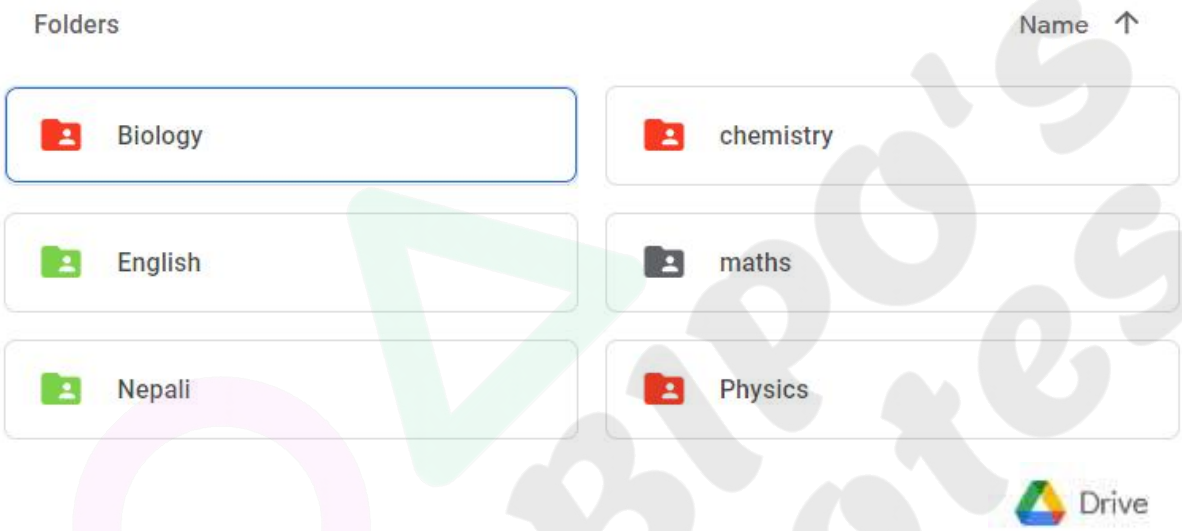
$$\therefore \lambda = \frac{\beta d}{D} = \frac{10^{-6} \times 10^{-6}}{2} = 0.5 \times 10^{-6} m.$$

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

Bipin Khatri

(Bipo)

Class 12 complete notes and paper collection.



Feedbacks:

admin@bipinkhatri.com.np | bipinkhatri.ram@gmail.com

Contact:

@im.bipo www.bipinkhatri.com.np @im.bipo