Study Material - Physics / Sem. 2 / Interference - Problems / Dr. T. Kar / Class 4

(1) A light source emits light of two wave-lengths 4300 Å and 5100 Å. The source is used in a double slit experiment. The distance between the source and the screen is 1.5 m and the distance between the slits is 0.025 mm. Calculate the separation between the third order bright fringes due to these two wavelengths.

Ans.

Given: $\lambda_1 = 4300$ Å, $\lambda_2 = 5100$ Å, $n = 3$, $D = 1.5$ m

$d = 0.025$ mm

$x_1 = \frac{nD}{d}\lambda_1$ and $x_2 = \frac{nD}{d}\lambda_2$

$\therefore x_2 - x_1 = \frac{nD}{d}(\lambda_2 - \lambda_1) = \text{-----}$ cm.

(2) Interference fringes are observed with a biprism of refracting angle 1° and refractive index 1.5 on a screen 80 cm away from it. If the distance between the source and the biprism is 20 cm, calculate the fringe width when the wavelength of light used is 6900 Å.

(2)

Ans.

Given: $\mu = 1.5$, $\alpha = 1^\circ = \frac{\pi}{180}$ radian

$a = 20$ cm, $D = (80+20)$ cm $= 100$ cm

$\lambda = 6900$ Å

$\beta = \frac{D\lambda}{d}$ and $d = 2a(\mu-1)\alpha$

$\therefore \beta = \frac{D\lambda}{2a(\mu-1)\alpha} = \text{-----}$ cm.

(3.) A two slit Young's interference experiment is done with monochromatic light of wavelength 6000 Å. The slits are 2mm apart and the fringes are observed on a screen placed 10 cm away from the slits and it is found that the interference pattern shift by 5 mm, when a transparent plate of thickness 0.5 mm is introduced in the path of one of the rays. What is the refractive index of the transparent plate?

Ans.

$$t = \frac{(\Delta x)\lambda}{\beta(\mu-1)} = \frac{(\Delta x)\lambda}{\left(\frac{D\lambda}{d}\right)(\mu-1)}$$

$$= \frac{(\Delta x)d}{D(\mu-1)} \Rightarrow \mu - 1 = \frac{(\Delta x)d}{tD};\ \mu = ?$$

Given: $t = 0.5$ mm, $\Delta x = 5$ mm, $d = 2$ mm

$D = 10$ cm

(3)

(4.) A beam of monochromatic light of wavelength 5.82×10^{-7} m falls normally on a glass wedge with wedge angle of 20 seconds of an arc. If the refractive index of glass is 1.5, find the number of dark fringes per cm of the wedge length.

Ans. Given: $\alpha = 20$ sec of an arc

$$= \frac{20\pi}{60 \times 60 \times 180} \text{ radian}$$

$\lambda = 5.82 \times 10^{-7}$ m, $\mu = 1.5$

$\beta = \frac{\lambda}{2\mu\alpha} \Rightarrow$ no. of fringes / cm $= \frac{1}{\beta} = ?$

(5.) In a Newton's ring experiment with a source of light emitting two wavelengths $\lambda_1 = 6 \times 10^{-5}$ cm and $\lambda_2 = 4.5 \times 10^{-5}$ cm. It is found that the n th. dark ring due to λ_1 coincides with the (n+1) th. dark ring due to λ_2. If the radius of curvature of the curved surface of the lens is 90 cms, find the diameter of the n th. dark ring for λ_1.

Ans. $D_n^2 = \frac{4n\lambda_1 R}{\mu} = \frac{4(n+1)\lambda_2 R}{\mu}$

or, $n\lambda_1 = (n+1)\lambda_2$ or, $\frac{n+1}{n} = \frac{\lambda_1}{\lambda_2}$

or, $1 + \frac{1}{n} = \frac{\lambda_1}{\lambda_2}$ or, $\frac{1}{n} = \frac{\lambda_1 - \lambda_2}{\lambda_2}$

or, $n = \frac{\lambda_2}{\lambda_1 - \lambda_2} = ?$

Given: $\lambda_1 = 6 \times 10^{-5}$ cm

$\lambda_2 = 4.5 \times 10^{-5}$ cm, $R = 90$ cm

$\therefore D_n = \sqrt{4n\lambda_1 R} = ?$

(6.) In a Newton's ring experiment, the incident light consists of two close wavelengths ($\lambda_1 = 5890\,Å$ & $\lambda_2 = 5896\,Å$). The radius of curvature of the curved surface is 100 cm. Calculate the distance from the point of contact of the lens and the glass plate at which the rings will disappear.

Ans. Fringes will disappear, if nth order bright ring due to λ_1 coincides with nth order dark ring of λ_2.

$$\therefore \frac{2(2n+1)\lambda_1 R}{\mu} = \frac{4n\lambda_2 R}{\mu} \Rightarrow n = ?$$

$\therefore r_n = ??$

(7.) Newton's rings are formed in reflected light of wave-length 600 nm with a combination of plane plate of glass and a plano-convex lens of 1 m radius of curvature. On introducing a liquid between the lens and the plate, it is found that the diameter of 7th dark ring decreases by 0·54 mm. Find out the refractive index of liquid.

Ans. $(D_n^2)_{Dark} = \frac{4n\lambda R}{\mu}$

Given: $n = 7$, $\lambda = 600\,nm$, $R = 1\,m$

$(D_7^2)_{air} = ? \Rightarrow (D_7)_{air} = ?$

$(D_7)_{liq} = [(D_7)_{air} - 0 \cdot 54]\,mm$

$\therefore \mu = \frac{(D_7)^2_{air}}{(D_7^2)_{liq}} = ?$

(8.) When a narrow monochromatic source of light is placed at a distance of 50 cm from biprism ($\mu = 1 \cdot 5$), the distance between two consecutive fringes formed on a screen placed at a distance of 100 cm from the biprism was found to be 0·012 cm. Find the obtuse angle of the biprism. The wavelength of light employed is 5893 Å.

Ans: $d = 2a(\mu-1)\alpha$

$$\lambda = \frac{d\beta}{D} = \frac{2a(\mu-1)\alpha\beta}{D}$$

Given: $\lambda = 5893\,Å$

$\beta = 0\cdot012$ cm, $\mu = 1\cdot5$, $a = 50$ cm,

$D = 150$ cm

$$\alpha = \frac{\lambda D}{2a(\mu-1)\beta} \text{ radian}$$

$= ----$ degree

∴ obtuse angle of biprism $= (180 - 2\alpha)$ deg.

(9.) A vertical rectangular soap film of length 15 cm is illuminated by light of wavelength 5890 Å. 12 dark and 11 bright fringes are seen on the film when it is about to break. Find the angle between the two surfaces of the film if its refractive index is $\left(\frac{4}{3}\right)$.

Ans. The no. of dark fringes are 12 and hence the no. of spacing between them is 11. Therefore, fringe width $\beta = \frac{15}{11}$ cm

Again, $\beta = \frac{\lambda}{2\mu\alpha}$

$\therefore \alpha = \frac{\lambda}{2\mu\beta}$

= - - - - radian.

Given:
$\lambda = 5890 \mathring{A}$
$\mu = \frac{4}{3}$

(10.) In Newton's ring experiment, the radius of n th. dark ring is 4mm and the radius of (n+5) th. dark ring 6mm. If the radius of curvature of lower surface of lens is 10 metres, find the wavelength of light used and the ring number 'n'.

Ans. $\lambda = \frac{r_{n+5}^2 - r_n^2}{5R}$ where, $r_{n+5} = 6$ mm, $r_n = 4$ mm, $R = 10$ m

= - - - . cm

Again, $r_n^2 = Rn\lambda \Rightarrow n = ??$