Tutorial Sheet-2 (Interference)

1. In Fresnel's biprism experiment sodium light is used and bands of 0.02 cm in width are observed at a distance of 100 cm from the slit. A convex lens is then put between the observer and the prism to give an image of the source at a distance of 100 cm from the siit. The distance apart of the images is found to be 0.75 cm, the lens being 25 cm from the slit. Calculate the wavelength of sodium light.

2. In Fresnel's biprism experiment the angle of the glass prism is 3^0 and $\mu = 1.5$. Interference fringes are formed with source of wavelength 6000 Å located 10 cm from the biprism and source to screen distance is 100 cm. Find the maximum number of fringes that can be observed. [45]

3. A biprism of obtuse angle 176^0 is made of glass of refractive index 1.5. A slit illuminated with monochromatic light is placed 20 cm behind and the width of interference fringes formed on a screen 80 cm in front of biprism is found to be 8.25×10^{-3} cm. Calculate the wavelength of light. [5.757×10^{-5} cm.]

4. In a biprism experiment the eye-piece was placed at a distance of 120 cm from the source. The distance between two virtual images was found to be 0.075 cm. Find the wavelength of light source, if eye-piece micrometer is moved through a distance 1.888 cm for 20 fringes cross the field of view. [5900 Å]

5. A Fresnel biprism arrangement is set with sodium light (λ=5893 A) and in the field of view of the eye piece we get 62 fringes. How many fringes shall we get if we replace the source by mercury lamp using (a) green filter (λ=5461 Å) (b) violet filter (λ=4358 Å) .[67, 83]

6. In Newton's rings experiment the diameter of 4^{th} and 12^{th} dark rings are 0.400 cm and 0.700 cm respectively. Deduce the diameter of 20^{th} dark ring. [0.906 cm]

7. If in a Newton's rings experiment, the air in the inter space is replaced by a liquid of refractive index 1.33, in what proportion would the diameters of the rings change? [0.867]

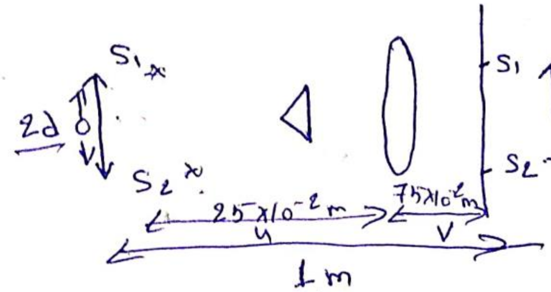
8. Light containing two wavelengths λ_1 and λ_2 falls normally on a Plano convex lens of radius of curvature R resting on a plane glass plate. If n^{th} dark ring due to λ_1 coincides with $(n+1)^{th}$ dark ring due to λ_2 then prove that the radius of n^{th} dark ring of wavelength λ_1 is $\sqrt{\dfrac{\lambda_1 \lambda_2 R}{(\lambda_1 - \lambda_2)}}$.

Solution of Tutorial Sheet -2

[1]

$\beta = 2 \times 10^{-4}\, m$

$D = 1\, m$



$I_m = 75 \times 10^{-4}\, m$

we know that $\frac{I}{O} = \frac{v}{u} \Rightarrow \frac{75 \times 10^{-4}}{2d} = \frac{75 \times 10^{-2}}{25 \times 10^{-2}}$

$2d = 25 \times 10^{-4}\, m$

$\beta = \lambda D / 2d \Rightarrow \lambda = \frac{\beta \times 2d}{D}$

$\lambda = \frac{2 \times 10^{-4} \times 25 \times 10^{-4}}{} = 50 \times 10^{-8}$

$\boxed{\lambda = 5000\, A^\circ}$

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[2] $\alpha = 3^\circ = \frac{3 \times \pi}{180} \text{ radian} \Rightarrow \frac{\pi}{60} \text{ radian}$

$\mu = 1.5 \quad \lambda = 6000 \times 10^{-10}\, m$

$D = 1\, m$

$a = 10 \times 10^{-2}\, m$

(we know that $2d = 2a(\mu - 1)\alpha$

$\therefore 2d = 2 \times 10 \times 10^{-2} (1.5 - 1) \frac{\pi}{60} = \frac{0.5 \times 3.14 \times 10^{-2}}{3} = \frac{1.57 \times 10^{-2}}{3}$

$= 0.523 \times 10^{-2} = 52.3 \times 10^{-4}\, m$

We know that $x = \frac{n \lambda D}{2d}$

since x is the distance between images which is proportional to the distance between source point i.e $2d$

$$2d = \frac{n\lambda D}{2d}$$

$$n = \frac{(2d)^2}{\lambda D} = \frac{(52.3 \times 10^{-4})^2}{6000 \times 10^{-10} \times 1}$$

$$= \frac{2735.29 \times 10^{-8}}{6 \times 10^{-7}}$$

$$= 455.8 \times 10^{7-8}_{m} = 45.5$$

$$\boxed{n \simeq 45}$$

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[3] $$\alpha = \frac{180-176}{2} = 2^\circ = \frac{2 \times \pi}{180} = \frac{\pi}{90} \text{ radian}$$

$\mu = 1.5$

$u = a = 20 \times 10^{-2}$ m $v = b = 80 \times 10^{-2}$ m

$\beta = 8.25 \times 10^{-5}$ m

$\lambda = ?$

$D = a + b = u + v$
$= 1$ m

$$\beta = \frac{\lambda D}{2d} \Rightarrow 8.25 \times 10^{-5} =$$

$$\lambda = \frac{2d \times 8.25 \times 10^{-5}}{1}$$

we know that $2d = 2a(\mu-1)\alpha$

$$\lambda = 2 \times 20 \times 10^{-2}(1.5-1)\frac{3.14}{90} \times 8.25 \times 10^{-5} = \frac{2 \times 2\cancel{0} \times 0.5 \times 3.14 \times 10^{-2}}{9\cancel{0}} \times 8.25 \times 10^{-5}$$

$$= 2 \times \frac{3.14}{9} \times 10^{-2} \times 8.25 \times 10^{-5}$$

$$= \frac{2 \times 3.14 \times 8.25}{9} \times 10^{-7} = \frac{51.81}{9} \times 10^{-7} = 5.757 \times 10^{-7}_{m}$$

$$\lambda = 5.757 \times 10^{-7} \text{ m} \Rightarrow \boxed{\lambda = 5.757 \times 10^{-5} \text{ cm}}$$

[4] $D = 1.2\ m$ $2d = 75 \times 10^{-5}\ m$.

$\lambda = ?$ $x = 1.888 \times 10^{-2}\ cm$

$n = 20$

$$x = \frac{n \lambda D}{2d} \qquad \lambda = \frac{x \times 2d}{n D}$$

$$\lambda = \frac{1.888 \times 10^{-2} \times 75 \times 10^{-5}}{20 \times 1.2}$$

$$\lambda = \frac{141.6 \times 10^{-7}}{24} = 5.9 \times 10^{-7}\ m$$

$$\lambda = 59000\ A^\circ$$

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[5] $\lambda_1 = 5893\ A^\circ$ $n_1 = 62$

$\lambda_2 = 5461\ A^\circ$ $n_2 = ?$

$\lambda_3 = 4358\ A^\circ$ $n_3 = ?$

$$x = \frac{n \lambda D}{2d} \Rightarrow n_1 \lambda_1 = \left(\frac{x \times 2d}{D}\right) \quad (i)$$

This is ~~same~~ for all case

similarly

$$n_2 \lambda_2 = \left(\frac{x \times 2d}{D}\right) \quad (ii) \quad \text{and} \quad n_3 \lambda_3 = \frac{x \times 2d}{D} \quad (iii)$$

from (i), (ii) and (iii) we get

$$n_1 \lambda_1 = n_2 \lambda_2 = n_3 \lambda_3$$

$$n_2 = \frac{n_1 \lambda_1}{\lambda_2} = \frac{62 \times 5893}{5461} = 66.90 \quad n_2 = 67$$

$$n_3 = \frac{n_1 \lambda_1}{\lambda_3} = \frac{62 \times 5893}{4358}$$

$$n_3 = 83.8 \approx 83$$

[6]

$n = 4$

$n+p = 12 \Rightarrow p = 8$

$D_{n+p}^2 - D_n^2 = 4p\lambda R$

$D_{12}^2 - D_4^2 = 4 \times 8 \times \lambda \times R$ (I)

$D_{20}^2 - D_4^2 = 4 \times 16 \times \lambda \times R$ (II)

$$\frac{D_{12}^2 - D_4^2}{D_{20}^2 - D_4^2} = \frac{8}{16} \quad 2$$

$2(D_{12}^2 - D_4^2) = D_{20}^2 - D_4^2 \Rightarrow D_{20}^2 = 2D_{12}^2 - D_4^2 = 2(0.7)^2 - (0.4)^2$

$D_{20}^2 = 0.98 - 0.16 = 0.82 \Rightarrow D_{20} = \sqrt{0.82} \Rightarrow D_{20} = 0.906$ cm

[7]

) We know that

$$D_n^2 = \frac{4n\lambda R}{\mu}$$

or $\mu = \frac{4n\lambda R}{D_n^2} = \mu \propto \frac{1}{D_n^2}$

or $D_n^2 \propto \frac{1}{\mu} \Rightarrow D_n \propto \frac{1}{\sqrt{\mu}} \Rightarrow$

$D_n \propto \frac{1}{\sqrt{1.33}} = \frac{1}{1.153} \Rightarrow 0.86\cancel{7}$

[8] the diameter of nth dark ring $D_n^2 = 4n\lambda_1 R$ (i)

the diameter of $(n+1)$th " " $D_{n+1}^2 = 4(n+1)\lambda_2 R$ (ii)

According to question $D_n^2 = D_{n+1}^2$

thus we have $\cancel{4} n \lambda_1 \cancel{R} = \cancel{4}(n+1)\lambda_2 \cancel{R} \Rightarrow n\lambda_1 = (n+1)\lambda_2$

or $n = \dfrac{\lambda_2}{\lambda_1 - \lambda_2}$ (iii)

now from (i) and (iii) we get

$$D_n^2 = 4n\lambda_1 R = \frac{4\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2} \Rightarrow \left(\frac{D_n}{2}\right)^2 = \frac{\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2}$$

$$r_n^2 = \frac{\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2} \Rightarrow \boxed{r_n = \sqrt{\frac{\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2}}}$$