KATHMANDU UNIVERSITY
DHULIKHEL KAVRE

Subject..PHY 101..........

Assignment No. 2

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<Q.17>: Two coherent sources of intensity ratio β interfere. Prove that in interference pattern

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{2\sqrt{\beta}}{1+\beta}$$

Soln:

Let I_1 and I_2 be the intensity of two coherent sources.

According to question,

$$\frac{I_1}{I_2} = \beta \qquad \text{or } I_1 = \beta I_2$$

We know,

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

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

Now,

$$I_{max} - I_{min} = I_1 + 2\sqrt{I_1 I_2} + I_2 - I_1 + 2\sqrt{I_1 I_2} - I_2$$

$$= 4\sqrt{I_1 I_2}$$

$$I_{max} + I_{min} = I_1 + 2\sqrt{I_1 I_2} + I_2 + I_1 - 2\sqrt{I_1 I_2} + I_2$$

$$= 2(I_1 + I_2)$$

So,

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{4\sqrt{I_1 I_2}}{2(I_1 + I_2)}$$

$$= \frac{2\sqrt{\beta I_2 \cdot I_2}}{\cancel{2}(\beta I_2 + I_2)}$$

$$= \frac{2\cancel{I_2}\sqrt{\beta}}{\cancel{I_2}(1+\beta)}$$

So,

$$\frac{I_{max} - I_{min}}{I_{max} + I_{min}} = \frac{2\sqrt{\beta}}{1+\beta}$$

Hence, proved.

<Q.27>: Show that the two waves with wave functio(n) $E_1 = 6.00 \sin(100\pi t)$ and $E_2 = 8.00 \sin(100\pi t + \pi/2)$ add to give a wave function $E_R \sin(100\pi t + \phi)$. Find the required values of E_R and ϕ.

Soln:

Given,

$E_1 = 6.00 \sin(100\pi t)$

$E_2 = 8.00 \sin(100\pi t + \pi/2)$

Here,

$E_1^0 = 6.00$

$E_2^0 = 8.00$ and $\phi_p = \pi/2$

Now,

$$E_R = \sqrt{E_1^{0\,2} + E_2^{0\,2} + 2E_1^0 E_2^0 \cos \phi_p}$$

$$= \sqrt{6^2 + 8^2 + 2 \times 6 \times 8 \times \cos \pi/2}$$

$\therefore E_R = 10$

And,

$$\tan \phi = \frac{E_2 \sin \phi_p}{E_1 + E_2 \cos \phi_p}$$

$$= \frac{8 \times \sin \pi/2}{6 + 8 \times \cos \pi/2}$$

$$= 4/3$$

$\phi = 53.13°$

<Q.5>: The distance between two coherent sources in Young's double slit experiment is 0.2mm and interference is observed on a screen 80cm from the sources. If wavelength is 6000 Å,

i) How far is second bright fringe from central bright fringe?

ii) How far is the second dark fringe from central bright fringe?

Soln:

Given,

distance between two coherent sources (d) = 0.2mm
= 0.2×10^{-3} m

distance between source and screen (D) = 80 cm
= 0.8 m.

Wavelength of light (λ) = 6000 Å
= 6000×10^{-10} m

Now, we know,

For nth bright fringe,

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

So,

$$y_2 = \frac{2 \times 6000 \times 10^{-10} \times 0.8}{0.2 \times 10^{-3}} = 0.0048 \text{ m} = 0.48 \text{ cm}$$

For nth dark fringe,

$$y_n = (2n-1) \frac{\lambda D}{2d}$$

So,

$$y_2 = \frac{(2 \times 2 - 1) \times 6000 \times 10^{-10} \times 0.8}{2 \times 0.2 \times 10^{-3}} = 0.0036 \text{ m}$$

= 0.36 cm

<Q.4>: In Young's double slit experiment, the slits are separated by 0.28 mm and the screen is 1.4 m away. The distance between the central bright fringe and the fourth bright fringe is 1.2 cm. Find frequency of the light used.

Soln:

Given,

separation between slits (d) = 0.28 mm

$= 0.28 \times 10^{-3}$ m

separation between source and screen (D) = 1.4 m

Distance between central bright and 4th bright fringe (y_4) = 1.2 cm

$= 1.2 \times 10^{-2}$ m

frequency of light used (f) = ?

We know,

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

$$\text{or, } \lambda = \frac{y_4 d}{4D}$$

$$\text{or, } f = \cancel{\frac{y_4 d \times}{4D}} \quad \frac{4vD}{y_4 d}$$

[∵ velocity of light in air = 3×10^8 m/s]

So,

$$f = \frac{4 \times 3 \times 10^8 \times 1.4}{1.2 \times 10^{-2} \times 0.28 \times 10^{-3}}$$

$$\therefore f = 5 \times 10^{14} \text{ Hz}$$

(Q.5): Calculate the minimum thickness of a soap bubble film that results in constructive inteference in the reflected light if the film is illuminated ~~who~~ by light whose wavelength is 600 nm in space. The refractive index of soap film is 1.33. What if the film is twice as thick? Does it produce constructive interference?

Soln:

Given,

Refractive index of soap $(\mu) = 1.33$

Wavelength of light $(\lambda) = 600\,nm = 600 \times 10^{-9}\,m$

Let the thickness be t.

Now,

for constructive interference.

$$2\mu t = (2n+1)\frac{\lambda}{2}$$

In case of minimum thickness, $n = 0$.

So,

$$t_{min} = \frac{\lambda}{4\mu}$$

$$= \frac{600 \times 10^{-9}}{4 \times 1.33}$$

$\therefore t_{min} = 1.12 \times 10^{-7}\,m \approx 112\,nm$

We know,

constructive interference occurs only for odd multiple of $\lambda/4\mu$.

So, if the film is twice as thick, the constructive interference doesn't occur for a thin film.

<Q.67: A thin film of oil ($\mu = 1.25$) is located on smooth, wet pavement. When viewed perpendicular to the pavement, the film reflects most strongly red light at 640 nm and reflects no green light at 512 nm. How thick is the oil film.

Soln:

Given,

refractive index of oil $(\mu) = 1.25$

Here,

the layers are air, ~~water~~ oil and water

ie, $1 < 1.25 < 1.33$. So, the light reflected from both top and the bottom surface suffers phase reversal.

Now,

For constructive interference, $2\mu t = n\lambda_{cons}$ — (i)

For destructive interference, $2\mu t = \frac{(2n+1)}{2}\lambda_{des}$. — (ii)

Dividing eqn (i) by (ii), we get.

$$1 = \frac{2n\lambda_{cons}}{(2n+1)\lambda_{des}} \quad \text{or,} \quad \frac{2n+1}{2n} = \frac{\lambda_{cons}}{\lambda_{des}}$$

$$\text{or,} \quad 1 + \frac{1}{2n} = \frac{\lambda_{cons}}{\lambda_{des}}$$

$$\text{or,} \quad 1 + \frac{1}{2n} = \frac{640}{512} \qquad \therefore n = 2$$

So,

thickness of film $(t) = \frac{n\lambda}{2\mu}$ [from eqn (i)]

$$= \frac{2 \times 640 \times 10^{-9}}{2 \times 1.25}$$

$$\therefore t = 512 \times 10^{-9}\,m = 512\,nm$$

<Q.7>: In Newton's ring experiment, the diameter of 12th dark ring changes form 1.40 to 1.27 cm as a liquid is introduced between the lens and the glass plate. Calculate the refractive index of the liquid.

Soln.

Given,

diameter of 12th dark ring in air $(D_a) = 1.40\,cm$

diameter of 12th dark ring in liquid $(D_l) = 1.27\,cm$

Refractive index of liquid $(\mu) = ?$

We know,

$$D_{air}^2 = 4n\lambda R \quad \text{—— (i)}$$

$$D_{liquid}^2 = \frac{4n\lambda R}{\mu} \quad \text{—— (ii)}$$

Dividing eqn (i) by (ii),

$$\frac{D_{air}^2}{D_{liquid}^2} = \mu$$

$$\text{or } \mu = \frac{(1.40)^2}{(1.27)^2} = 1.215$$

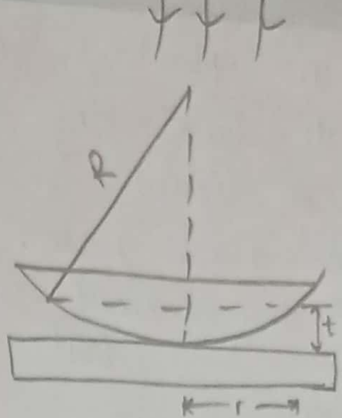
<Q.8>: In a Newton's ring experiment, a planoconvex glass $(\mu = 1.52)$ lens having radius $(r = 5.00\,cm)$ is placed on a flat plate as shown. When light of wavelength $\lambda = 650\,nm$ is incident normally, 55 bright rings are observed with the last one precisely on the edge of the lens.

a) what is radius of curvature of convex lens?

b) what is the focal length of lens?

Soln:

For bright fringe,



$$2t = (2n-1) \times \frac{\lambda}{2}$$

or, $t = \dfrac{(2 \times 55 - 1) \times 6.5 \times 10^{-7}}{4}$

$\therefore t = 1.77 \times 10^{-5}$ m

Here,
from figure,

$$t = R - \sqrt{R^2 - r^2}$$

or, $R^2 - r^2 = R^2 - 2Rt + t^2$

or, $2Rt = t^2 + r^2$

or, $R = \dfrac{t^2 + r^2}{2R} = \dfrac{(0.05)^2 + (1.77 \times 10^{-5})^2}{2 \times 1.77 \times 10^{-5}}$

$\therefore R = 70.6$ m

Using Lens makes formula,

$$\frac{1}{f} = ({}_a\mu_g - 1)\left(\frac{1}{R_1} + \frac{1}{R_2}\right)$$

Here, $R_2 = \infty$.

So,
$$\frac{1}{f} = (1.52 - 1) \times \frac{1}{R}$$

on $f = \dfrac{70.6}{0.52}$ $\therefore f = 136.77$ m.