12. INTERFERENCE AND DIFFRACTION

HOMEWORK SOLUTIONS

1. Given :

Path difference = $85.5\ \lambda$

Also, Path difference = $42.5\ \mu m$

= 42.5×10^{-6} m

To Find :

i) Whether the point is bright or dark

ii) Wavelength of light (λ) = ?

Solution :

Path difference is $85.5\ \lambda$ which can be expressed as $\frac{171}{2}\ \lambda$

Which can be further expressed as

$(2n - 1)\frac{\lambda}{2}$ where n = 86

$\therefore$ The point is dark

$\therefore\ 171\frac{\lambda}{2} = 42.5 \times 10^{-6}$

$\therefore\ \lambda = \frac{42.5 \times 2 \times 10^{-6}}{171}$

$\therefore\ \lambda = \frac{85.0 \times 10^{6}}{171}$

$\therefore\ \lambda = \frac{85 \times 10^{-6}}{171}$

$\therefore\ \lambda = Al\ [\log 85 - \log 171] \times 10^{-6}$

$\therefore\ \lambda = Al \begin{bmatrix} 1.9294 \\ -\ 2.2330 \\ \bar{1}.6964 \end{bmatrix} \times 10^{-6}$

$\therefore\ \lambda = 4.971 \times 10^{-7}$

$\therefore\ \lambda = 4971 \times 10^{-10}$ m

$\therefore\ \lambda = 4971$ A.U.

2. Given :

Path Diff = $(1.8 - 1.23) \times 10^{-5}$ m

= 0.57×10^{-5} m

λ = 6000 AU

= 6×10^{-7} m

To Find :

No of Bright or Dark Band = ?

Solution :

Consider,

$\frac{\text{Path Diff}}{\lambda} = \frac{0.57 \times 10^{-5}}{6 \times 10^{-7}}$

= 9.5

$\therefore$ Path Diff = $9.5\ \lambda$

= $\left(10 - \frac{1}{2}\right)\lambda$

$\therefore$ 10^{th} dark Band is formed.

3. Given :

Path Diff = 8.8 – 8.7

= 0.1 cm

λ = 5000 AU

= 5×10^{-7} m

To Find :

Point is bright or dark = ?

Solution :

Consider,

$\frac{\text{Path Diff}}{\lambda} = \frac{10^{-3}}{5 \times 10^{-7}}$

= $\frac{10000}{5}$

= 20000

Path Diff = $2000\ \lambda$

Comparing with, Path Diff of BB = $n\lambda$

$\therefore$ Point is a Bright.

4. Given :

D = 5 + 75

= 80 cm = 0.8 m

λ = 5890 A.U

= 5.89×10^{-7} m

X = 9.424×10^{-2} cm

= 9.424×10^{-4} m

To Find :

d = ?

Formula :

$\lambda = \frac{Xd}{D}$

Solution :

From formula

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

$$= \frac{5.89\times10^{-7}\times0.8}{9.424\times10^{-4}}$$

$$= 0.5\times10^{-3}\ m$$

$\therefore$ d = 0.5 mm

5. Given :

λ = 5200 AU

$\therefore \lambda = 5200 \times 10^{-10}$ m

$\therefore X_1 - X_2$ = 1.3 mm

$\therefore X_1 - X_2 = 1.3 \times 10^{-3}$ m

$D_1 - D_2$ = 50 cm

= 0.5 m

To Find :

d = ?

Formula :

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

Solution :

$$X_1 - X_2 = \frac{\lambda D_1}{d} - \frac{\lambda D_2}{d}$$

$$\therefore X_1 - X_2 = \frac{\lambda}{d}(D_1 - D_2)$$

$$\therefore d = \frac{\lambda(D_1 - D_2)}{X_1 - X_2}$$

$$\therefore d = \frac{5200\times10^{-10}\times0.5}{1.3\times10^{-3}}$$

$$\therefore d = \frac{5.2\times10^{-7}\times0.5}{1.3\times10^{-3}}$$

$\therefore d = 2\times10^{-4}$

$\therefore$ d = 0.2 mm

6. Given :

X_1 = 0.2 mm

$= 2\times10^{-4}$ m

$D_2 - D_1$ = 50 cm

= 0.5 m

X_2 = 0.3 mm

$= 3\times10^{-4}$ m

d = 0.3 cm

$= 3\times10^{-3}$ m

To Find :

λ = ?

Formula :

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

Solution :

$$X_2 - X_1 = \frac{\lambda}{d}D_2 - \frac{\lambda}{d}D_1$$

$$X_2 - X_1 = \frac{\lambda}{d}(D_2 - D_1)$$

$$\therefore \lambda = \frac{d(X_2 - X_1)}{D_2 - D_1}$$

$$= \frac{3\times10^{-3}\times(0.3-0.2)\times10^{-3}}{0.5}$$

$= 6\times10^{-4}\times10^{-3}$

$= 6000\times10^{-10}$

= 6000 AU

7. Given :

$x'_{10} - x'_2$ = 0.12 cm

$\therefore x'_{10} - x'_2 = 0.12\times10^{-2}$ m

u = 20 cm

$\therefore$ u = 0.2 m

v = 80 cm

$\therefore$ v = 0.8 m

$d_1 = 4.5$ mm $= 4.5\times10^{-3}$ m

$d_2 = 2$ mm $= 2\times10^{-3}$ m

To Find :

λ = ?

Formula :

For dark band,

$$x'_n = \frac{(2n-1)\lambda D}{2d}$$

$$d = \sqrt{d_1\times d_2}$$

Solution :

D = u + v

$\therefore$ D = 0.8 + 0.2 m

$\therefore$ D = 1 m

$x'_{10} - x'_2 = \frac{19\lambda D}{2d} - \frac{3\lambda D}{2d}$

$0.12 \times 10^{-2} = \frac{16 \lambda D}{2d}$

$= \frac{8\lambda D}{d}$

$d = \sqrt{d_1 \times d_2}$

$\therefore d = \sqrt{4.6 \times 2 \times 10^{-6}}$

$\therefore d = 3 \times 10^{-3} m$

$\therefore \lambda = \frac{0.12 \times 2d \times 10^{-2}}{16 D}$

$\therefore \lambda = \frac{0.24 \times \sqrt{d_1 \times d_2 \times 10^{-2}}}{16 \times 1}$

$\therefore \lambda = \frac{0.24 \times 3 \times 10^{-2} \times 10^{-3}}{16}$

$\therefore \lambda = 0.045 \times 10^{-5}$

$\therefore \lambda = 4500$ A.U.

8. Given :

$x_5 = 2.97 \times 10^{-4} m$

$\lambda = 4800$ A.U.

$= 4800 \times 10^{-10} m$

$D = 1m$

To Find :

$a = ?$

Formula :

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

Solution :

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

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

$= \frac{5 \times 4800 \times 10^{-10} \times 1}{29.7 \times 10^{-4}}$

$= \frac{5 \times 48 \times 10^{-3}}{29.7}$

$= \frac{2400 \times 10^{-3}}{297}$

$= Al\ [\log 2400 - \log 297] \times 10^{-3}$

$= Al \begin{bmatrix} 3.3802 \\ -2.4728 \end{bmatrix} \times 10^{-3}$

$= Al\ (0.9074) \times 10^{-3}$

$= 8.079 \times 10^{-3} m$

$= 8.079$ mm

9. Given :

$\lambda = 5000$A.U.

$d = 0.5$ mm

$= 5 \times 10^{-4} m$

$D = 100$ cm

$= 1$ m

To Find : $x_{11} - x_1 \Rightarrow$ bright bands

$x'_7 - x'_3 \Rightarrow$ dark bands

Formula : $x_n = \frac{n\lambda D}{d}$

$x_m = (2m - 1) \frac{\lambda D}{2d}$

Solution :

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

$\therefore x_{11} - x_1 = \frac{11\lambda D}{d} - \frac{\lambda D}{d}$

$= \frac{10 \times 5000 \times 10^{-10} \times 1}{5 \times 10^{-4}}$

$= 1 \times 10^{-2}$

$= 1$ cm

10. Given :

$D = 1.2$ m

$d = 4mm = 4 \times 10^{-3}$ m

Distance of ninth dark band on either side of Central bright band $\Delta x = 2.652$ mm

$= 2.652 \times 10^{-3}$

Find : Wave length $\lambda = ?$

Solution :

Distance between nineth dark band on either side of central band

$\Delta x = x'_9 + x'_9$

$2.652 \times 10^{-3} = (2m - 1) \frac{\lambda D}{2d} + (2m - 1) \frac{\lambda D}{2d}$

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

$2.652 \times 10^{-3} = \dfrac{17\lambda D}{d}$

$\therefore \lambda = \dfrac{2.652 \times 10^{-3} \times 4 \times 10^{-3}}{17 \times 1.2}$

$= \dfrac{2.652 \times 10^{-6}}{17 \times 3 \times 10^{-1}}$

$= \dfrac{2652 \times 10^{-9}}{51 \times 10^{-1}}$

$= 52 \times 10^{-8}$

$= 5200 \times 10^{-10} m$

$= 5200$ A.U

11. Given :

$x_{20} = 8$ mm

$= 8 \times 10^{-3} m$

To Find : 30th bright band $\Rightarrow x_{30}$

30th dark band $\Rightarrow x'_{30}$

Formula :

$x_n = \dfrac{n\lambda D}{d}$

$x_m = (2m - 1)\dfrac{\lambda D}{2d}$

Solution :

$x_n = \dfrac{n\lambda D}{d}$

$\dfrac{x_{20}}{x_{30}} = \dfrac{20}{30}$

$\therefore x_{30} = \dfrac{x_{20} \times 3}{2}$

$= \dfrac{8 \times 10^{-3} \times 3}{2}$

$= 12 \times 10^{-3}$

$= 12$ mm

$\dfrac{x_n}{x_m} = \dfrac{\dfrac{n\lambda D}{d}}{(2m - 1)\dfrac{\lambda D}{2d}}$

$\therefore \dfrac{x_{30}}{x'_{30}} = \dfrac{30 \times 2}{59}$

$\therefore x'_{30} = \dfrac{12 \times 10^{-3} \times 59}{60}$

$= 11.8$ mm

12. Given :

$\lambda = 4800$ Å

$= 4.8 \times 10^{-7}$ m

$D = (20 + 80)$ cm

$= 100$ cm $= 1$ m

$d = 0.3$ cm $= 3 \times 10^{-3}$ m

To Find :

$X_5 + X'_5 = ?$

Solution :

$X_5 = \dfrac{5\lambda D}{d}$

$X'_5 = (2 \times 5 - 1)\dfrac{\lambda D}{2d}$

$= 4.5\dfrac{\lambda D}{d}$

$\therefore X_5 + X'_5 = \dfrac{5\lambda D}{d} + 4.5\dfrac{\lambda D}{d}$

$= 9.5\dfrac{\lambda D}{d}$

$= \dfrac{9.5 \times 4.8 \times 10^{-7} \times 1}{3 \times 10^{-3}}$

$= 1.52 \times 10^{-3}$ m

$= 1.52$ mm

13. Given :

$\lambda_1 = 5890$ AU

$= 5890 \times 10^{-10}$ m

$20x_1 = 2.3$

$30x_2 = 2.8$

To Find : $\lambda_2 = ?$

Formula :

$\dfrac{X_1}{X_2} = \dfrac{\lambda_1}{\lambda_2}$

Solution :

$\dfrac{X_1}{X_2} = \dfrac{\lambda_1}{\lambda_2}$

$\therefore \lambda_2 = \dfrac{\lambda_1 X_2}{X_1}$

$= \frac{5890 \times 2.8 \times 20}{2.3 \times 30} \times 10^{-10}$

$= \frac{5890 \times 28 \times 2}{23 \times 3} \times 10^{-10}$

$\therefore \lambda_2 = \frac{5890 \times 56}{69} \times 10^{-10}$

$=$ Al [log 5890 + log 56 - log 69] $\times 10^{-10}$

$$= \text{A}l \left[\begin{array}{r} 3.7701 \\ \underline{1.7482} \\ 5.5183 \\ - \ \underline{1.8388} \\ 3.6795 \end{array} \right] \times 10^{-10}$$

$= 4.780 \times 10^{3} \times 10^{-10}$

$=$ 4780 AU

14. Given :

d = 0.8 mm

$\therefore$ d = 0.8×10^{-3} m

D = 1.2 m

X = 0.79 mm

$\therefore$ X = 0.79×10^{-3} m

To Find :

λ = ?

Formula :

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

Solution :

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

$\therefore \lambda = \frac{X d}{D}$

$\therefore \lambda = \frac{0.79 \times 10^{-3} \times 0.8 \times 10^{-3}}{1.2}$

$\therefore \lambda = \frac{79 \times 8 \times 10^{-3} \times 10^{-3} \times 10^{-3}}{1.2}$

$\therefore \lambda = \frac{632 \times 10^{-9}}{12 \times 10^{-1}}$

$\therefore \lambda = 52.67 \times 10^{-9} \times 10^{1}$

$\therefore \lambda = 52.67 \times 10^{-8}$

$\therefore \lambda = 5267 \times 10^{-10}$ m

$\therefore \lambda$ = 5267 A.U.

15. Given :

λ = 5900 Å

d = 10^{-3} m

D = 1 m

To Find :

X = ?

Formula :

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

Solution :

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

$\therefore X = \frac{5900 \times 1 \times 10^{-10}}{10^{-3}}$

$\therefore X = 5900 \times 10^{-7}$

$\therefore X = 0.59 \times 10^{-3}$ m

$\therefore$ X = 0.59 mm

16. Given :

d = 0.1 cm

$\therefore$ d = 0.1×10^{-2} m

D = 1 m

X = 0.058 cm

$\therefore$ X = 0.058×10^{-2} m

To Find :

λ = ?

Formula :

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

Solution :

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

$\therefore \lambda = \frac{X d}{D}$

$\therefore \lambda = \frac{0.058 \times 10^{-2} \times 0.1 \times 10^{-2}}{1}$

$\therefore \lambda = 0.0058 \times 10^{-4}$

$\therefore \lambda = 5800 \times 10^{-10}$ m

$\therefore \lambda$ = 5800 A.U.

17. Given :

$d = 0.5$ mm
$= 0.5 \times 10^{-3}$ m
$= 5 \times 10^{-4}$ m
$D = 100$ cm $= 1$ m
$X_9 - X'_2 = 8.835$ mm

[Assuming both bright and dark fringes are on same side of centre of fringe pattern]

$= 8.835 \times 10^{-3}$ m

To Find :

$\lambda = ?$

Formula :

$$\lambda = \frac{Xd}{D}$$

Solution :

Since distance of n^{th} bright band

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

$$X_9 = \frac{9\lambda D}{d}$$

Since distance of n^{th} dark band from center

$$X'_2 = (2 \times 2 - 1)\frac{\lambda D}{2d}$$

$$= \frac{3\lambda D}{2d}$$

$$\text{Now } X_9 - X'_2 = \frac{9\lambda D}{d} - \frac{3\lambda D}{2d} = \frac{15\lambda D}{2d}$$

$$\therefore \quad \lambda = \frac{2d(x_9 - x'_2)}{15D}$$

$$= \frac{2 \times 5 \times 10^{-4} \times 8.835 \times 10^{-3}}{15 \times 1}$$

$$= 5.89 \times 10^{-7} \text{ m}$$

$$\therefore \quad \lambda = 5890 \text{ A.U}$$

18. Given :

$d = 0.3$ mm $= 3 \times 10^{-4}$ m
$X = 1.5$ mm $= 1.5 \times 10^{-3}$ m
$D = 75$ cm $= 0.75$ m

To Find :

$\lambda = ?$
$X' = ?$
$X'' = ?$

Formula :

$$\lambda = \frac{Xd}{D}$$

Solution :

$$\lambda = \frac{Xd}{D}$$

$$\lambda = \frac{1.5 \times 10^{-3} \times 3 \times 10^{-4}}{0.75}$$

$$= 6 \times 10^{-7} \text{ m}$$

$$\therefore \quad \lambda = 6000 \text{ A.U.}$$

i) The distance of the screeen is doubled

$$X = \frac{\lambda D}{d} \text{ and}$$

$$X' = \frac{\lambda D'}{d}$$

$$\therefore \quad \frac{X'}{X} = \frac{D'}{D} = \frac{2D}{D} = 2$$

$$\therefore \quad X' = 2X$$

$$= 2 \times 1.5 \times 10^{-3}$$

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

$$\therefore \quad X' = 3 \text{ mm}$$

ii) The separation between the slots is doubled

$$X = \frac{\lambda D}{d} \text{ and}$$

$$X'' = \frac{\lambda D}{d'}$$

$$\therefore \quad \frac{X''}{X} = \frac{d}{d'} = \frac{d}{2d} = \frac{1}{2}$$

$$\therefore \quad X'' = \frac{X}{2}$$

$$= \frac{1.5 \times 10^{-3}}{2}$$

$$= 0.75 \times 10^{-3} \text{ m}$$

$$\therefore \quad X'' = 0.75 \text{ mm}$$

19. Given :

$X_1 = 0.4$ mm

$\therefore X_1 = 0.4 \times 10^{-3}$ m

$D_1 = 1$ m

$D_2 = (1 - 0.25)$ m

$\therefore D_2 = 0.75$ m

To Find :

$X_1 - X_2 = ?$

Formula :

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

Solution :

We know that,

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

$$X \propto D$$

$$\therefore \frac{X_2}{X_1} = \frac{D_2}{D_1}$$

$$\therefore X_2 = \frac{0.75 \times 0.4 \times 10^{-3}}{1}$$

$$X_2 = 0.3 \times 10^{-3} \text{ m}$$

$\therefore$ Change in fringe width

$$X_1 - X_2 = (0.4 \times 10^{-3}) - (0.3 \times 10^{-3})$$

$$\therefore X_1 - X_2 = 0.1 \times 10^{-3} \text{ m}$$

$$\therefore X_1 - X_2 = 0.1 \text{ mm}$$

20. Given :

$D = 1$ m

$\lambda = 6000\ A^0 = 6 \times 10^{-7}$ m

$d_1 = 3.6$ mm

$\therefore d_1 = 3.6 \times 10^{-3}$ m

$d_2 = 2.5$ mm

$\therefore d_2 = 2.5 \times 10^{-3}$ m

To Find :

$X = ?$

Formula :

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

$$d = \sqrt{d_1 \times d_2}$$

Solution :

$$d = \sqrt{d_1 \times d_2}$$

$$\therefore d = \sqrt{3.6 \times 2.5 \times 10^{-6}}$$

$$\therefore d = \sqrt{36 \times 25 \times 10^{-6} \times 10^{-2}}$$

$$\therefore d = 6 \times 5 \times 10^{-4}$$

$$\therefore d = 30 \times 10^{-4} \text{ m}$$

$$\therefore d = 3 \text{ mm}$$

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

$$\therefore X = \frac{6 \times 10^{-7} \times 1}{30 \times 10^{-4}}$$

$$\therefore X = 0.2 \times 10^{-3} \text{ m}$$

$$\therefore X = 0.2 \text{ mm}$$

21. Given :

$d = 0.8$ mm

$= 8 \times 10^{-4}$m

$D = 1.2$ m

$X = 0.75$ mm

$= 7.5 \times 10^{-4}$m

To Find : λ

Formula : $X = \dfrac{\lambda D}{d}$

Solution :

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

$$\lambda = \frac{Xd}{D}$$

$$= \frac{7.5 \times 10^{-4} \times 8 \times 10^{-4}}{1.2}$$

$$= \frac{75 \times 8 \times 10^{-8}}{12}$$

$$= 5000 \times 10^{-10}$$

$$= 5000 \text{ A.U.}$$

22. Given :

$D = 60$ cm $= 60 \times 10^{-2}$ m

$\lambda = 5460\ A^0 = 5460 \times 10^{-10}$m

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

To Find :

change in fringe width = ?

Solution :

Fringe width is given by

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

$$= \frac{5460 \times 10^{-10} \times 60 \times 10^{-2}}{3 \times 10^{-3}}$$

$$= 109200 \times 10^{-9}$$

$$= 0.1092 \text{ mm}$$

$$= 10.92 \times 10^{-2} \text{ mm}$$

$$d_1 = d - 1 = 3 - 1 = 2\text{mm}$$

Since $X \propto \frac{1}{d}$

thus, $\frac{X_1}{X} = \frac{d}{d_1}$

$\therefore \quad X_1 = \frac{d}{d_1} X$

$$= \frac{3}{2} \times 10.92 \times 10^{-2}$$

$$= 16.38 \times 10^{-2} \text{ mm}$$

Change in fringe width $\Delta X = X_1 - X$

$$= 16.38 \times 10^{-2} - 10.92 \times 10^{-2}$$

$$= 5.46 \times 10^{-2} \text{ mm}$$

23. Given :

$d_2 = 1/2\ d_1$

$D_2 = 2D_1$

Solution :

$X = \lambda D/d$

$\therefore \quad X_1 = \frac{\lambda D_1}{d_1}$

$X_2 = \frac{\lambda D_2}{d_2}$

$\therefore \quad \frac{X_1}{X_2} = \frac{D_1}{D_2} \times \frac{d_2}{d_1}$

$\frac{X_1}{X_2} = \frac{D_1}{2D_1} \times \frac{1/2d_1}{d_1}$

$X_1 = \frac{1}{4} X_2$

$\therefore$ Fringe width increases by 4 times

24. Given :

$$D_2 = D_1 + \frac{10}{100} D_1$$

$$= \frac{110}{100} D_1$$

$$= \frac{11}{10} D_1$$

$$d_2 = d_1 - \frac{20}{100} d_1$$

$$= \frac{80}{100} d_1$$

$$= \frac{8}{10} d_1$$

To Find :

Percentage change in 'β'

Formula :

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

Solution :

$$\frac{\beta_2}{\beta_1} = \frac{D_2}{D_1} \times \frac{d_1}{d_2}$$

$$= \frac{11}{10} \times \frac{10}{8}$$

$$\frac{\beta_2}{\beta_1} = \frac{11}{8}$$

$$\frac{\beta_2 - \beta_1}{\beta_1} \times 100 = \frac{11 - 8}{8} \times 100$$

$$\% \beta = \frac{300}{8}$$

$$= 37.5\ \%\ \text{increase}$$

25. Given :

$\lambda_g = 5350$ AU

$= 5350 \times 10^{-10}$ m

$D_g = 1.28$ m

$\lambda_r = 6400$ AU

$= 6400 \times 10^{-10}$ m

$D_r = ?$

Formula :

$$\frac{\lambda_g}{\lambda_r} = \frac{D_r}{D_g}$$

Solution :

$$D_r = \frac{\lambda_g D_g}{\lambda_r}$$

$$= \frac{5350 \times 10^{-10} \times 1.28}{6400 \times 10^{-10}}$$

$$= \frac{107 \times 128 \times 10^{-2}}{128}$$

$$= 1.07 \text{ m}$$

26. Given :

$D_1 = 1\text{ m}$

$D_2 = 80\text{ cm} = 0.8\text{ m}$

To Find : $\dfrac{\lambda_1}{\lambda_2}$

Formula :

$$\frac{\lambda_1}{\lambda_2} = \frac{D_2}{D_1}$$

Solution :

$$\frac{\lambda_1}{\lambda_2} = \frac{D_2}{D_1}$$

$$\therefore \frac{\lambda_1}{\lambda_2} = \frac{0.8}{1} = \frac{8}{10} = \frac{4}{5}$$

27. Data :

$$\frac{I_{max}}{I_{min}} = \frac{25}{9}$$

$$\frac{w_1}{w_2} = ?$$

Solution :

$$\frac{I_{max}}{I_{min}} = \frac{25}{9}$$

$$\frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{25}{9}$$

$$\frac{(a_1 + a_2)}{(a_1 - a_2)} = \frac{5}{3}$$

By Comp-Div,

$$\frac{2a_1}{2a_2} = \frac{5+3}{5-3}$$

$$\frac{a_1}{a_2} = \frac{8}{2} = \frac{4}{1}$$

$$\frac{a_1}{a_2} = \frac{4}{1}$$

$$\frac{a_1^2}{a_2^2} = \frac{16}{1}$$

$$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{w_1}{w_2} = \frac{16}{1}$$

$$\frac{w_1}{w_2} = \frac{16}{1}$$

28. Data :

$I_1 = I$ and $I_2 = 4I$

Solution :

$$I_R = I_1 + I_2 + 2\sqrt{I_1 I_2}\cos\phi$$

When

$$\phi = \frac{\pi}{2}$$

$$I_R = I + 4I + 2\sqrt{I.rI.}\ .\cos\frac{\pi}{2}$$

$$= 5I \qquad \left(\because \cos\frac{\pi}{2} = 0\right)$$

When $\phi = \pi$,

$I_R = I + 4I + .\cos p$

$= 5I + 2.2I(-1) \quad (\because \cos\pi = -1)$

$= 5I - 5I = I$

29. Given :

$$\frac{I_1}{I_2} = \frac{81}{1}$$

To Find :

$$\frac{I_{max}}{I_{min}} = ?$$

Formula :

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$$

Solution :

$$\frac{I_1}{I_2} = \frac{a_1^2}{a_2^2} = \frac{81}{1}$$

$$\frac{a_1}{a_2} = \frac{9}{1}$$

$\therefore$ $a_1 = 9\,a_2$

$$\frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2}$$

$$\frac{I_{max}}{I_{min}} = \frac{(9a_2 + a_2)^2}{(9a_2 - a_2)^2} = \frac{(10a_2)^2}{(8a_2)^2}$$

$$= \frac{100a_2^2}{64a_2^2}$$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{25}{16}$$

30. Given :

$X_1 = 3.2 \times 10^{-4}$ m

$\lambda_1 = 6400$ A.U.

$\therefore$ $\lambda_1 = 6400 \times 10^{-10}$ m

$\lambda_2 = 4000$ A.U.

$\therefore$ $\lambda_2 = 4000 \times 10^{-10}$ m

To Find :

$X_1 - X_2 = ?$

Formula :

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

Solution :

We know that,

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

$$\therefore \frac{X_2}{X_1} = \frac{\lambda_2}{\lambda_1}$$

$$\therefore X_2 = \frac{\lambda_2}{\lambda_1} \times X_1$$

$$\therefore X_2 = \frac{4000}{6400} \times 3.2 \times 10^{-4}$$

$X_2 = 2 \times 10^{-4}$ m

$\therefore$ Change in fringe width

$X_1 - X_2 = (3.2 \times 10^{-4}) - (2 \times 10^{-4})$

$X_1 - X_2 = 1.2 \times 10^{-4}$ m

$\therefore$ $X_1 - X_2 = 0.12$ mm

31. Given :

$\lambda_r = 6400$ A.U

X_3 = Centre of 3rd bright band for red

X_4 = Centre of 4th bright band for blue

$X_3 = X_4$

To Find :

$\lambda_b = ?$

Formula :

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

Solution :

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

$$X_3 = \frac{3\lambda_r D}{d} \quad \text{and}$$

$$X_4 = \frac{4\lambda_b D}{d}$$

But

$X_3 = X_4$

$$\therefore \frac{3\lambda_r D}{d} = \frac{4\lambda_b D}{d}$$

$\therefore$ $3\lambda_r = 4\lambda_b$

$$\therefore \lambda_b = \frac{3 \times \lambda_r}{4}$$

$$= \frac{3}{4} \times 6400$$

$\therefore$ $\lambda_b = 4800$ A.U

32. Given :

$D = 70$ cm

$= 0.7$ m

$d = 0.42$ mm

$= 4.2 \times 10^{-4}$ m

$x'_4 = 3.15$ mm

$= 3.15 \times 10^{-3}$ m

$x'_4 = x_3$

To Find : $\frac{\lambda_1}{\lambda_2}$

Formula :

$x_m = (2m - 1)\frac{\lambda D}{2d}$

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

Solution :

$x_m = (2m - 1)\frac{\lambda D}{2d}$

$\lambda = \frac{x_m 2d}{D(2m - 1)}$

$= \frac{3.15 \times 10^{-3} \times 2 \times 4.2 \times 10^{-4}}{0.7 \times 7}$

$= \frac{3.15 \times 8.4 \times 10^{-7}}{4.9}$

$= \frac{3.15 \times 84 \times 10^{-7}}{49}$

$= 5.40 \times 10^{-7}$

$= 5400$ AU

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

$\lambda = \frac{x_n d}{nD}$

$= \frac{3.15 \times 10^{-3} \times 4.2 \times 10^{-4}}{3 \times 0.7}$

$= 6.30 \times 10^{-7}$

$= 6300$ AU

33. Given :

$\lambda_r = 6000$ AU

$= 6000 \times 10^{-10}$ m

$\lambda_b = 4800$ AU

$= 4800 \times 10^{-10}$ m

$(x_{n+1})_b = (x_n)_r$

To Find : n = ?

Formula :

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

Solution :

$(x_n)_r = (x_{n+1})_b$

$\frac{n\lambda_r D}{d} = (n+1)\frac{\lambda_b D}{d}$

$\therefore n\lambda_r = (n+1)\lambda_b$

$\therefore 6000\, n = (n+1)4800$

$\therefore 1200\, n = 4800$

$\therefore n = 4$

34. Given :

$D = 1$ m

$x_{10} = 0.22$ cm

$\therefore x_{10} = 0.22 \times 10^{-2}$ m

$u = 25$ cm

$\therefore u = 0.25$ m

$d_1 = 0.93$ cm

$\therefore d_1 = 0.93 \times 10^{-2}$ m

To Find :

$\lambda = ?$

Formula :

$u + v = D$

$\frac{d}{d_1} = \frac{u}{v}$

$x_n = \frac{n\lambda D}{d}$ (for bright band)

Solution :

$D = u + v$

$v = D - u$

$\therefore v = 1 - 0.25$

$\therefore v = 0.75$ m

$\frac{d}{d_1} = \frac{u}{v}$

$\therefore d = \frac{0.25 \times 0.93 \times 10^{-2}}{0.75}$

$\therefore d = \frac{25 \times 93 \times 10^{-2}}{7500}$

$\therefore d = \frac{2325 \times 10^{-2}}{7500}$

$\therefore d = 0.31 \times 10^{-2}$ m

$\therefore x_{10} = \frac{10\lambda D}{d}$

$0.22 \times 10^{-2} = \frac{10\lambda \times 1}{0.31 \times 10^{-2}}$

$\therefore \lambda = \frac{0.22 \times 0.31 \times 10^{-4}}{10}$

$\therefore \lambda = 0.022 \times 0.31 \times 10^{-4}$

$\therefore \lambda = 0.00682 \times 10^{-4}$

$\therefore \lambda = 6820$ A.U.

35. Given :

$D = 1$ m

$d_1 = 0.7$ cm

$\therefore d_1 = 0.7 \times 10^{-2}$ m

$v = 70$ cm

$\therefore v = 0.7$ m

$\lambda = 5892$ A.U.

$\therefore \lambda = 5892 \times 10^{-10}$ m

To Find :

100 X = ?

Formula :

$D = u + v$

$\frac{d}{d_1} = \frac{u}{v}$

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

Solution :

$D = u + v$

$\therefore u = D - v$

$\therefore u = 1 - 0.7$

$\therefore u = 0.3$ m

$\therefore \frac{d}{d_1} = \frac{u}{v}$

$\therefore d = \frac{u\, d_1}{v}$

$\therefore d = \frac{0.3 \times 0.7 \times 10^{-2}}{0.7}$

$\therefore d = 0.3 \times 10^{-2}$ m

$100\,(X) = \frac{100\,\lambda D}{d}$

$\therefore 100\,(X) = \frac{100 \times 5892 \times 10^{-10} \times 1}{0.3 \times 10^{-2}}$

$\therefore 100\,(X) = \frac{5892 \times 10^{-5}}{3}$

$\therefore 100\,(X) = 19.64 \times 10^{-3}$ m

$\therefore 100\,(X) = 19.64$ mm

36. Given :

$D = 1$ m

$x_{25} = 4$ mm $= 4 \times 10^{-3}$ m

$d_1 = 4.5$ mm

$= 4.5 \times 10^{-3}$ m

$d_2 = 2$ mm

$= 2 \times 10^{-3}$ m

To Find : λ

Formula :

$d = d_1 d_2$

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

Solution :

$x_n = \frac{n\lambda D}{d_1 d_2}$

$\therefore \lambda = \frac{x_n \sqrt{d_1 d_2}}{nD}$

$= \frac{4 \times 10^{-3} \sqrt{4.5 \times 10^{-3} \times 2 \times 10^{-3}}}{25 \times 1}$

$= \frac{12 \times 10^{-6}}{25}$

$= \frac{120 \times 10^{-7}}{25}$

$= 4.8 \times 10^{-7}$

$= 4800 \times 10^{-10}$

$= 4800$ AU

37. Given :

$\lambda = 4890\ A^o = 4890 \times 10^{-10}$ m

$d = 0.5$ cm

$\therefore d = 0.5 \times 10^{-2}$ m

$D = 40$ cm

$\therefore D = 40 \times 10^{-2}$ m

To Find :

(Distance between dark and bright band)

$\frac{X}{2} = ?$

Formula :

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

Solution :

$\therefore \quad X = \dfrac{\lambda D}{d}$

$\therefore \quad X = \dfrac{4890 \times 10^{-10} \times 40 \times 10^{-2}}{0.5 \times 10^{-2}}$

$\therefore \quad X = \dfrac{4890 \times 4 \times 100 \times 10^{-10}}{5}$

$\therefore \quad X = 3912 \times 10^{-8}$

$\therefore \quad X = 3.912 \times 10^{-5}$

$\therefore \quad \dfrac{X}{2} = \dfrac{3.912}{2} \times 10^{-5}$

$\therefore \quad \dfrac{X}{2} = 1.956 \times 10^{-2}$ mm

38. Data :

D = 2m

a = 0.2 mm

= 2×10^{-4} m

x = 5 mm

= 5×10^{-3} m

To Find :

λ = ?

Solution :

For first minimum, $\sin\theta = \dfrac{\lambda}{a}$

If θ is small and measured in radian,then $\sin\theta = \theta$

$\therefore \quad \theta = \dfrac{\lambda}{a}$

Also $\theta = \dfrac{x}{D}$

$\therefore \quad \lambda = \dfrac{x}{D} a$

$= \dfrac{5 \times 10^{-3}}{2} \times 2 \times 10^{-4}$

$\therefore \quad \lambda = 5 \times 10^{-7}$ m

$\therefore \quad \lambda = 5000$ Å

39. Given :

a = 0.14 mm

= 14×10^{-5} m

D = 2 m

x_2 = 1.6 cm = 16×10^{-3} m

n = 2

To Find :

λ = ?

Formula :

Distance of 2nd dark band from central minima,

$x_2 = \dfrac{n\lambda D}{a}$

Solution :

$x_2 = \dfrac{2\lambda D}{a}$

$16 \times 10^{-3} = \dfrac{2\lambda \times 2}{14 \times 10^{-5}}$

$\lambda = 56 \times 10^{-8}$ m

= 5600 A.U.

40. Given :

α = 20^0

λ = 6600 A.U

= 6.6×10^{-7} m

μ = 1 (for air)

To Find :

d = ?

Formula :

$d = \dfrac{1.22\lambda}{2\mu \sin\alpha}$

Solution :

$d = \dfrac{1.22\lambda}{2\mu \sin\alpha}$

$d = \dfrac{1.22 \times 6.6 \times 10^{-7}}{2 \times 1 \times \sin 20^0}$

$= \dfrac{1.22 \times 6.6 \times 10^{-7}}{2 \times 0.3420}$

$= \dfrac{1.22 \times 6.6 \times 10^{-7}}{0.684}$

$\therefore \quad d = 11.77 \times 10^{-7}$

$\therefore \quad d = 11770$ A.U

41. Given :

a = 20 cm

= 0.2 m

λ = 5900 A.U

= 5.9×10^{-7} m

To Find :

$d\theta$ = ?

Formula :

$$d\theta = \frac{1.22\lambda}{a}$$

Solution :

$$d\theta = \frac{1.22\lambda}{a}$$

$$d\theta = \frac{1.22 \times 5.9 \times 10^{-7}}{0.2}$$

$\therefore$ $d\theta$ = 3.599×10^{-6} rad

42. Data :

λ = 5890 Å

= 5.890×10^{-7} m

Numerical aperture (N.A.) = 0.12

To Find :

Limit of resolutin d = ?

R.P = ?

Solution :

$$d = \frac{\lambda}{2\text{N.A.}}$$

$$= \frac{5.890 \times 10^{-7}}{2 \times 0.12}$$

= 2.454×10^{-6} m

$$\text{R.P} = \frac{1}{d}$$

$$= \frac{1}{2.545 \times 10^{-6}}$$

= 0.4075×10^{6}

= 1.075×10^{5} per meter

43. Given :

λ = 4000A.U. = 4 x 10^{-7}m

d = 0.5 x 10^{-6} m

To Find :

Numerical aperture = ?

Formula :

N.A. = $\mu \sin \theta$

Solution :

The limit of resolution of microscope

$$d = \frac{\lambda}{2\mu \sin \theta}$$

$$\therefore \quad \mu \sin \theta = \frac{\lambda}{2d}$$

$$\mu \sin \theta = \frac{4 \times 10^{-7}}{2 \times 0.5 \times 10^{-6}}$$

$\mu \sin \theta$ = 4 x 10^{-1}

$\mu \sin \theta$ = 0.4 m