Diffraction of light

Q.1. A point source of light of wavelength $\lambda = 0.50\ \mu m$ is located at a distance 100 cm in front of diaphragm with round aperture of radius $r = 1.0$ mm. Find the distance b between the diaphragm and the observation point for which the no of Fresnel zones in aperture equal to $k = 3$.

Solution

$$r_n^2 = \frac{k\, ab\, \lambda}{a+b}$$

for periphery of k th zone

$$a r_k^2 + b r_k^2 = k ab \lambda$$

$$b = \frac{a r_k^2}{k a \lambda - r_k^2} =$$ Substitute the value and $k=3$

$$= 2 \text{ meter}$$

Q.2. A Diaphragm with round aperture whose radius r can be varied during experiment is placed between point source of light and screen. The distance from diaphragm to source and screen are equal to $a = 100$ cm and $b = 125$ cm. Determine the wave length of light if the intensity maximum at centre of diffraction pattern of screen is observed $r_1 = 1.0$ mm and next maximum at $r_2 = 1.29$ mm.

Solution Suppose maximum intensity is obtained when the aperture contain k zone.

Hence a minimum will be obtained for K+1 zones. Another maximum will contain for K+2 zones. Hence

$$r_1^2 = \frac{K\lambda (ab)}{a+b}$$

$$r_2^2 = (K+2)\lambda \frac{ab}{a+b}$$

$$\lambda = \frac{a+b}{2ab}\left(r_2^2 - r_1^2\right)$$

Q. A plane monochromatic wave with intensity I_0 falls normally on an opaque disc closing first Fresnel zone for the observation point P. What did the intensity of light I at the point P become equal to after

a) half of the disc (along the diameter) was removed.

b) half of the external half of first Fresnel zone were removed (along the diameter)

Solution: a) Suppose the disc does not obstruct the lights at all the

$$A_{disc} + A_r = \frac{1}{2} A_{disc}$$ (because disc cover F. F. Zone only)

$$A_r = -\frac{1}{2} A_{disc}$$

Hence the amplitude when half of disc is removed along the diameter

$= \frac{1}{2} A_{dis} + A_r = \frac{1}{2} A_{di} - \frac{1}{2} A_{dis} = 0$

b) $A = \frac{1}{2} A_{ext} + A_{r}$

$= \frac{1}{2} A_{ext} + \frac{1}{2} A_{dis}$

$A_{dis} = A_{in} + i A_{out}$ — i for $\pi/2$ phase diff.

$A = -\frac{1}{2} A_{in}$

$I = \frac{1}{4} A_{in}^2$

on other hand $I_0 = \frac{1}{4} (A_{in}^2 + A_{out}^2)$

$= \frac{1}{2} A_{in}^2$

$$\boxed{I = \frac{1}{2} I_0}$$